SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXV] NUMBER 1940] NEW YORK, MARCH 8, 1913 [10 CENTS A COPY $5.00 A YEAR

From the Rocks Below the Lake. When the Dam is Built the Water will Reach a Point Above the Rock to the Extreme Right of the Picture.

THE SOUTH YUBA AND BEAR RIVER PROJECT, CALIFORNIA.—[See page 152.]

Preliminary Report to the Inventors' Guild—I*

The Guild's Relation to Patent Practise

By F. L. O. Wadsworth

THERE are three lines of effort—more or less distinct and separate in character—to which the Inventors' Guild can advantageously devote its attention. The first of these relates to greatly needed reforms, and changes in the present rules of practice, in the U. S. Patent Office and covers generally the whole field of activities of that office. The second relates to certain very desirable innovations in the procedure of the Federal courts in equity suits involving patents and patent rights. The third relates to the formulating and securing of international agreements in reference to patent laws in various countries, with a view of harmonizing those laws—now widely at variance—and thus enabling American inventors to secure proper protection abroad.

The order in which these fields of effort have been mentioned is not intended to in any way imply or indicate an order of relative importance. No such order can in fact be established. Changes and reform in one field will lap over and influence changes and improvements in the others. It is, however, convenient, in this first general review of the matter, to thus classify the subjects under discussion as belonging to one or the other of the above three main sub-divisions; and it is further convenient to sub-classify these subjects as follows:

I. Changes and Improvements in the U. S. Patent Office Practice and Procedure.
   (1) The Preparation of a Digest of, and Index to the State of the Art.
   (2) The Increase in the Efficiency of the U. S. Patent Office in the examination and amendment of applications.
   (3) The Reform of the present practice of Conducting Interference Suits and Appeals.
   (4) The re-organization of the Office and the appointment of a permanent commission and Board of Visitors to co-operate with the office in its work.

II. Changes in the Present Procedure of conducting Patent Suits.
   (5) The Establishment of a Court of Patent Appeals.
   (6) The correction of Present Abuses in the taking of testimony.
   (7) The acceleration of the conduct of Patent Causes so as to obtain a speedy and final adjudication of the issues.
   (8) The reduction of the Expenses of Litigation.
   (9) The Provision of a fixed Indemnity to complainant for infringement.
   (10) The Recognition of Plaintiff's Right to receive substantial damages and profits in case of infringement.

III. Improvement of the Status of American Inventors in Foreign Countries.
   (11) International Standardization of laws relating to patents and patent rights.
   (12) The Abolishment of the "working clause" in the laws of various foreign countries.
   (13) Establishment of Reciprocity provisions equalizing the rights of Americans in foreign countries with those of citizens of each foreign country in the United States.
   (14) International Recognition of the principles of Comity, i. e., the Recognition by the Courts of Different Countries of Adjudications by the Courts of the other Countries.

In the following very general consideration of each of the above subjects, no attempt has been made to completely or exhaustively discuss in detail the various questions which are involved in the matters under examination. Such a detail treatment would be impossible in the limits of such a preliminary report as this is designed to be. It would moreover be confusing rather than helpful. The difficulty which we will encounter, in any effort to improve present conditions either in our Patent Office, in our Federal Court procedure or in our international relationships, will *not* be to find enough to remedy, but will be to choose the lines of endeavor upon which we can concentrate with the prospect of securing the most immediate and effective results. The present brief review is therefore intended to be only suggestive rather than comprehensive; stimulative rather than definitive. It is not intended to be in any sense determinative of the policy which the Society may ultimately decide to adopt. I have put forward a number of suggestions, some of them my own, some of them derived from others; but these are not to be taken as final recommendations to the Society. They are submitted only as a basis for discussion, and with a view of stimulating criticism. The writer appreciates very fully the objections that can and undoubtedly will be made to these or any other changes in our present practice that may be put forward for consideration. No changes whatever should be undertaken until they have been most fully and carefully considered from every possible point of view. It would be far better to let our present system of patent practice—defective though it may be—remain in force, than it would be to make hasty and ineffective innovations that may only represent the ideas and hobbies of some particular men or group of individuals.

With these preliminary remarks I will take up in order and briefly discuss each of the topics outlined in the preceding classification of the general subject matter of this report.

(1) It is extremely difficult under present arrangements for any inventor to readily ascertain the state of the patent art in the particular field in which he is working. This is in part due to the very antiquated and imperfect method of classifying and indexing patents in the U. S. Patent Office, in part due to the overcrowded and congested conditions in that office and in part due to the lack of classified files and abridgments of patents in various public libraries. The Patent Office has very recently established a classification division but it has a very inadequate working force and distressingly little progress has been made. The number of issued U. S. patents is nearly one million[1] and the number of foreign patents granted is over two million. To classify this enormous amount of material properly and without undue delay needs a force of at least fifty men. The work of classification of these patents is moreover only a part of what needs to be done in order to give those interested, complete, up-to-date, and readily accessible knowledge of what has been done and is being done in any particular art. Indices and digests of the classified patents should be prepared and distributed at cost to all of the leading technological libraries of the country. A current publication, very different in character from the present *Official Gazette* should be *at once* inaugurated. This publication should be issued in *classified* parts or sections, each section containing a brief abstract, including one drawing and one or two selected claims, of each patent belonging to each particular sub-division or section of the general classification of the art. These parts—issued weekly like the present *Gazette* or far better only semi-monthly or monthly—could then be bound together into yearly volumes which would contain a chronological history of the development of each particular branch of the patent art. I think that the publication of the present *Official Gazette* should be abolished. It is bulky, cumbersome, and absolutely useless as a reference publication save to determine in a general way what any particular *numbered* patent may refer to. It contains absolutely no classification of patents as to their subject matter and in order to ascertain what is being done in any particular branch of the art, one must examine something like a thousand entries in the *Gazette* each week of the year; a task that no one can or will undertake.

(2) The subject of increasing the efficiency of the U. S. Patent Office is one that demands the most careful, deliberate, and impartial consideration. In some respects our Patent Office is the best in the world, and in some respects the system of that office is pretty nearly the worst. The various matters which demand attention in connection with this subject can be conveniently divided into sub-heads as follows:

(*a*) Increase in Plant and Office Force. Anyone who has given this matter the slightest consideration knows that the present office building is utterly inadequate and is overcrowded and congested to the point of danger. A new building particularly designed and adapted to the special needs of the Patent Office, and the public, is the first and immediate necessity of any effort for the permanent improvement in the efficiency of the Patent Office work.

(*b*) The present corps of examiners is as good a one as we can hope to secure under the present scale of payment. This is utterly inadequate and insufficient to attract and hold men of ability. The only reason that we have as efficient a force as we do have is due to the fact that the majority of the younger men in the office accept a temporary position there merely as a preliminary training for future work. As soon as they have acquired some experience—and have completed their law course—they leave the office to set up in patent practice for themselves. Only the scholastically inclined or the unambitious remain and such men form the staff from which are appointed our primary examiners, etc. The salaries of the lower and assistant examiners should be *decreased*, the salaries of the primary examiners and examiners-in-chief and of the commissioner, etc., greatly increased. The Commissioner, for example, should receive a salary of not less than $8,000 to $10,000 per annum; and the Assistant Commissioner and Examiners-in-Chief salaries of from $6,000 to $8,000; and the Principal and First Assistant Examiners salaries of from $4,000 to $6,000 per year; and all vacancies in the higher office should be invariably filled by promotion, *in order of merit and efficiency;* and not as now by appointment. There should, on the other hand, be more rigid qualification requirements adopted as to new appointments. No one should be allowed to enter the office as an examiner of any grade unless he has had some practical experience, in addition to a scholastic training; and in order to make a man eligible to promotion to the post of First Assistant or of Primary Examiner he should have had not less than two years' practical shop experience, and not less than one year's practical laboratory experience in the arts which his division embraces. Such practical training could be acquired by giving the Assistant Examiners leave of absence, say for six months out of every two years. Manufacturers and superintendents would be willing and anxious to give examiners on leave an opportunity to acquire this practical experience and training. There should be further provision for the immediate discharge of incompetent and stupid or prejudiced examiners, by the Commissioner, and provision whereby complaints and charges against examiners on such grounds of incompetency or unfairness may be brought to the attention of the Commissioner without the formality or expense of taking an appeal from the examiners' decisions. There should also be provision for the retirement on part pay of the officers and examiners after they have reached a certain age or have served for a certain period.

(*c*) Amendments of Applications. A rule of practice should be adopted requiring the filing of all arguments by applicant's attorneys in writing and allowing oral interviews with the examiners only on written petition which will appear as a part of the file history. The office letters should be prepared in duplicate, and one copy sent to the attorney in charge of the application; the other mailed directly to the applicant himself. Each letter of rejection by the office should refer expressly to the amendment which the applicant's attorney had made in the claims, stating for example "the claims as now amended are as follows." This practice would do more to break up the business of incompetent and dishonest patent solicitors than any other plan that can be easily put into effect. Under the present practice of conducting all correspondence with the applicant's solicitor, the former is frequently kept in ignorance of what is going on until the patent is issued and it is then frequently too late to correct mistakes due to the incompetency or carelessness of the attorney in charge of the case.

(*d*) Disbarment of Incompetent Patent Solicitors. A considerable percentage of patents now issued by the U. S. Patent Office are either absolutely worthless or are far narrower in scope than the real invention which they disclose. This is in part due to the lack of practical training of the members of the U. S. Patent Office force, but is due in far greater degree to the existence of a great horde of incompetent and unscrupulous individuals who advertise themselves widely as patent solicitors and are most prodigal in their promises to inventors. The Patent Office should adopt some rigid qualification requirements, which would tend to bar such men from practice.

(*e*) Changes in the payment of U. S. Patent Office Fees. The present practice is to require a payment of only $15 on the filing of the application, and $20 on the allowance and issue of the patent. This order of payment should—at the very least—be reversed. All of the work of the office is done before the patent is granted. Therefore most of the cost should be paid in advance, particularly as the work of the office may result in the application being finally rejected. The more equitable arrangement would be to require a payment of at least $25 on the filing of the application and the balance on the granting of the patent. This simple change would increase the revenues on the Patent Office $150,000 or $200,000 per year without adding a cent to the cost of any patent actually granted. Under such an arrangement it might be possible to *reduce* the Government fees, but this does not seem either necessary or desirable. Rather they should

* Chairman of the Professional Committee of the Inventors' Guild. This report was presented to the Guild at its November meeting, 1910, but is here published for the first time.

[1] The number of patents now issued very considerably *exceeds* one million.

be if anything raised, so as to tend to cut down the number of applications, and make it possible for the examiners to devote more time and study to each application. That in itself would greatly facilitate and expedite the progress of the case in the office, for any one of experience knows that many of the examiner's letters of rejection show very little consideration on his part of the real features of the invention before him. There should be at all events a provision for a graded scale of first fees, dependent upon the complexity of the applicant's specification and claims. To induce greater brevity and clearness of statement and to discourage needless multiplicity of claims, it might be provided that the applicant be required to pay an additional fee of $1 for each page exceeding three in original application, and a like fee for each and every claim, exceeding five, inserted either in the original application or by subsequent amendment.

(3) The present practice in conducting interference contests in the U. S. Patent Office is in many repects the worst of its kind in existence. It is a notorious fact that in such contests as at present conducted a poor contestant is practically at the mercy of a rich opponent. By instituting various obstructive proceedings; by prolonging almost *ad infinitum*, the taking of testimony all over the country—or even in foreign countries—and finally by carrying the case from one tribunal to another on motions, and appeals, the delays and expenses of the litigation may be piled up to such a degree as to absolutely compel the poor or even moderately circumstanced inventor to abandon his case. I have known of interference contests in which the cost—to one party alone—has run up to the enormous figure of nearly $40,000. Think of incurring such an expense in merely securing a judgment as to priority, and remember that the inventor's right to obtain a patent may still be contested on a mere technicality or even on an utterly fictitious claim of another party—by instituting public use proceedings—and remember finally that even after winning out in all these contests and securing a patent such a patent may be declared utterly worthless and invalid by the courts. Winning an interference in no way aids an inventor in afterwards sustaining his rights against infringers. The present practice in these cases is a disgrace to our patent system.[2]

[2] In this connection attention is called to an article "Some Hardships of Patent Infringement," by L. P. Alford in the *American Machinist* of February 10th, 1910.

Meteorology as an Exact Science*

Physical Laws Applied to the Study of Atmospheric Phenomena

By Prof. V. Bjerkne

In accordance with the natural division of the Earth into an atmosphere, a hydrosphere and a lithosphere, geophysical science comprises three parts: Physics of the Atmosphere, Physics of the Sea and Physics of the Solid Globe. The first two branches are closely related with one another, and I intend making them the center of my work as investigator and teacher.

The physics of the atmosphere and meteorology, though agreeing as far as the object of their investigation is concerned, are not identical in their scope. The difference between them might be expressed by recalling the fact that physics is an exact science, whereas one might be inclined to describe meteorology as a most inexact science. Meteorology only becomes exact, in so far as it develops into a physics of the atmosphere. This development forms the subject of the following considerations:

An interest in atmospheric phenomena was naturally awakened in Man at a very early period. The ancients had meteorological knowledge not only regarding the weather in their own country, but also regarding certain great periodical phenomena, such as the Indian monsoons. They were also acquainted with the physical laws and relations mainly concerned in the production of air currents, viz., Archimedes' law of hydrostatic buoyancy, and the expansion undergone by the air on heating. But there was no one to throw a bridge from one branch of knowledge to the other and to realize the causal connection. We can not therefore properly speak of a science of physics of the atmosphere among the ancients.

The age of discovery resulted in new additions to meteorological knowledge. Columbus discovered on his first voyage the trade winds, and subsequent navigators found the same winds in the Southern Hemisphere and renewed their acquaintance with the monsoons. The same period witnesses a remarkable development of physical science; a rational dynamics was founded, and the laws of hydrostatic buoyancy and thermal expansion were re-discovered. All preliminary conditions for recognizing a causal connection were thus given, and the happy inspiration came first to Halley who, on a two years' voyage through the Tropics had collected his observations. He states the case as follows: At the equator the air is heated strongly; it expands and becomes lighter and rises to higher altitudes, whence it flows off toward the poles. In order to effect a compensation, masses of air have to flow in from the North and South along the surface of the earth toward the equator, the winds thus produced being the trade winds. Halley also tried to account for the fact that the trade winds, instead of flowing along the meridian, have a component also in the direction of the equator, but his interpretation is not correct. Hadley it was who 50 years afterward showed this phenomenon to be due to the rotation of the earth, all air and sea currents being apparently deflected to an observer rotating with the Earth.

Halley's and Hadley's work can to a certain extent be compared with the feat achieved by Newton for astronomical science, when he taught how to calculate in advance the position of planets, when the initial position is given. Just as Newton's achievement was due to his applying to astronomy the results of a related science, mechanics, Halley and Hadley were indebted for their successes to the application of the results of the kindred doctrine of physics to meteorology. Still there was a great difference. Newton's solution of the astronomical task was quantitative, and astronomers have since been able numerically to predetermine the positions of planets. Halley and Hadley, however, had to be satisfied with a qualitative explanation of meteorological phenomena. The reason of this difference is evident. Astronomical observers in Newton's time supplied all the data on the actual position of the planets required for predetermination; meteorological observers at the time of Halley and Hadley on the other hand were still quite unable to give corresponding data on the condition of atmosphere. To this should be added the still rudimentary state of theoretical knowledge. Planets could be considered as isolated material points influencing one another in accordance with simple laws. Newton's mechanics was immediately adapted to problems of this kind. On the other hand, the laws ruling the equilibrium and motion of liquid and gaseous bodies, and the relations between mechanical work and heat were still unknown. Any further progress of meteorology thus was dependent, on one hand, on the development of the methods of observation, and, on the other, on the advances of theoretical physics.

The invention of the thermometer and barometer endowed meteorological observation with a precision it had so far lacked. At the beginning of the 19th century the enormous value of strictly simultaneous observation for the recognition of causal connections was at last realized. Great pains were frequently taken in collecting such data and in representing them synoptically on maps. Toward the middle of the last century, electrical telegraphy was for the first time placed in the service of synoptical meteorology, and this organization gave rise to the development of the present international public weather services.

However, the great hopes attached to this organization, when it was first called into being, were only partially realized. This was—not without some justification—put down to the fact that only observations of the lowest stratum of the atmospheric ocean were available. All data relating to the free atmosphere were missing, apart from the results of manned balloon trips undertaken by a few isolated investigators, such as Glaisher, with instruments still defective. However, the evolution of aerological methods, a thing of quite recent origin, connected with which are prominently the names of Assmann, Rotch and Teisserenc de Bort, now enabled the atmosphere to be sounded up to heights of 20 kilometers and more, by means of balloons and kites. Prof. Hergesell's endeavors have resulted in the perfecting of an international network from which the atmosphere over a large part of Europe is explored on predetermined days. Directly or indirectly the elements describing the actual state of the air can now be ascertained for all those points of the atmosphere which are penetrated by instruments. These elements are: The three components of velocity, pressure, density, temperature and moisture. By means of suitable methods of interpolation, the same factors can also be stated for any point situated within the explored region of the atmosphere. The task of meteorological observation may thus be said to have been solved, and it only remains for the future to furnish technical improvements.

Hand in hand with the development of methods of observation went a splendid progress of physical science. Toward the middle of the 18th century, Clairaut established the equations of hydrostatics and Euler those of hydrodynamics. In 1835, i. e., just 100 years after Hadley, Coriolis enunciated his wellknown theorem, which is now generally used in accounting for the deflection due to the rotation of the earth. After the invention of the thermometer and the barometer, the behavior of gases had been investigated experimentally, thus leading gradually to the Boyle-Gay Lussac law. The difference between the concepts of heat and temperature was realized and the laws of freezing and melting were determined. Guided by Sadi Carnot and Robert Mayer's revolutionary ideas, Helmholtz, Lord Kelvin, Clausius and other investigators erected the structure of thermodynamics.

Physical science had thus fulfilled the requirements it had to comply with. The seven variables which describe the state of atmosphere have been above enumerated. Physics now supplies also seven equations expressing the mutual connection between these variables, viz., the three hydrodynamical equations, the equation expressing the conservation of mass (equation of continuity) the state equation of gases and the equations derived from the two fundamental laws of thermodynamics. The problems of atmospheric physics thus become problems stated in mathematical terms, which can be subjected to a quantitative treatment with some chance of success.

At a time when physical science was undergoing this development, the theorems newly found were gradually applied to meteorological phenomena. On certain hypotheses it is possible so to simplify these problems as to give them either a purely dynamical or a purely thermodynamical character and to allow the corresponding differential equations to be integrated. We are indebted for important papers in this direction, which have doubtless elucidated many notions, to Ferrel, Guldberg and Mohn, Helmholtz, Hertz, Von Bezold, etc.

Belonging to a period previous to the inception of aerology, these papers had to be content with the treatment of ideal cases. Now, however, after aerological observation has been supplying all fundamental data on the state of the atmosphere, a problem is suggested which can no longer be put aside, viz., the problem of *mathematical predetermination of the weather*. Though the goal be still distant, and though the individual worker in the field has little chance ever to reach it, it is by no means premature to face its solution even now. The final goal being thus clearly prescribed, scientific investigation follows the right direction, and there is some hope of doing good preparatory work, provided the goal be never lost sight of. The way so far traversed by me and my collaborators has, it is true, only shown how far away we are as yet from the final goal. Still, many individual problems have been solved and many useful methods developed. Among other results should be mentioned the establishment of the principles of a graphical mathematics, which allows from the maps representing the distribution of pressures, densities, etc., other maps to be derived graphically, much as one equation is derived from the other by analytical means. It may be said that analytical methods would be quite unsuitable for the purpose at issue, there being no hope of ever succeeding in representing by mathematical formulæ the state of atmosphere at a given moment.

An objection sometimes raised against this kind of work is that a predetermination of the weather, even if it should be possible, would take far too much time to be utilized in practice. What is the use of learned men requiring three weeks to calculate what the weather does in three hours? Though the author does not hope personally to reach the goal, he would be more than content with calculating by many years' indefatigable work even the weather from one day to the other. This would, in fact, mean the scientific solution of the problem and practical achievements would soon be forthcoming.

"It may take years to bore a tunnel through a mountain. Many workers may not live to see the day of piercing the tunnel. Still, this will not prevent others from some day traversing the mountain at the speed of express trains."

* Authorized and revised abstract from inaugural address held on January 8th, 1913, at the University of Leipzig.

The Skyscraper of the Future*

A Retrospect and Forecast

By David H. Ray, Sc.D.

PROGRESS in building construction is nowhere better illustrated than by the three substantial buildings that have succeeded each other on the site of the Bankers' Trust Building in Wall Street, New York. In 1880 the Manhattan Trust Company erected a fine up-to-date eight-story commercial building on this corner, equipped with the very latest devices that only a wealthy concern can afford. Within the space of eleven years the building had grown so out of date that it was removed and the twenty-six story Gillender Building erected in 1891.

This skyscraper was built in the best manner of the time and equipped with every known convenience with the prospect of standing for centuries, yet in two decades it was demolished, thrown into the scrap-pile and the present Bankers' Trust Company Building of a height of thirty-eight stories erected in the place. Nor is this exceptional; the Thorley Building in New York, a modern steel structure, was demolished to make place for the present New York Times Building, and the Rand-McNally Building in Chicago, one of the early marvels of tall building construction in that city, has given way to a taller, more modern structure.

With the skyscraper approaching the age of thirty years, we find the first generation, so to speak, passing away. It seems scarcely credible on looking on the pictures of the larger American cities of thirty years ago that the marvellous change in the skyline all occurred in the span of one generation. And there is no indication of a slackening or decline in this activity. New York is still building enormous high buildings at an accelerated rate averaging about one each month of the year. The seemingly incredible point is now reached where a few of the earlier tall buildings are being removed to make place for higher ones. Structures regarded a score of years ago as destined to stand for centuries, as structures of such riveted strength and erected with such travail that it would be well-nigh impossible to take them down, are now old-fashioned, and eligible for the scrap-pile. Such is the pace of building progress in the Metropolis.

In 1913, it is literally easier to cut down a steel column than to cut down a tree or cut through a block of stone. With a portable oxygen-acetylene flame, steel work is now cut apart in a few minutes with no physical exertion. Indeed an anarchist or lunatic reckless of consequences could, single-handed, cut down any of the tall steel structures in a few hours if free from interference. So does science work miracles of invention and discovery, and from generation to generation multiply the facilities for weal and woe. Let no man attempt to prophesy, therefore, the marvels that the future may hold in store.

As the tall building enters upon its second generation, one naturally inquires,—What of the future? Can they be built higher? What is the limit? Disregarding for the moment the question of legal limitation and artificial restriction of height, it is evident that the answer is bound up with the scientific evolution of the years to come. At no time has the architect been more ready to seize and apply the last word in scientific research. Indeed, it is the price of his success and continued favor and prosperity. The architect who does not keep in touch with building progress and the latest application of science will soon find himself drifting steadily to the rear. Indeed even to stand still is to find oneself moving backward by contrast with the onward current. The modern tall building is a marvel of up-to-date scientific appliances. Without scientific engineering not only could not such buildings be constructed, but they could not be maintained or rendered habitable. It is apparent therefore that radical scientific discovery or invention will profoundly affect the future of these structures.

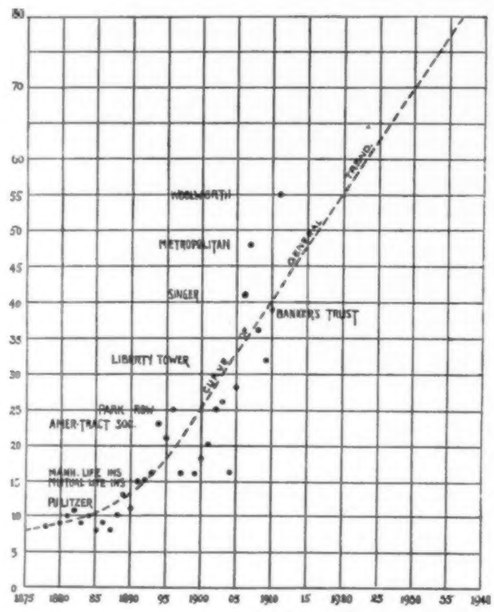


Diagram 1.—Showing the Tallest Building Each Year Since 1875.

It is only necessary to contrast a European building with a typical American building to realize the extent to which applied science dominates the latter. Sometime ago while escorting a group of visiting engineers, members of an International Congress of Engineers, through several of the larger buildings in New York city, a Russian engineer said to me, "Science is evident in everything, even in the sweeping and cleaning. Your skyscrapers are dollars invested scientifically!" Later pointing to the S on the dollar-sign, he said, "your captains of industry are the shrewd men who early guessed that that S stands for Science, who imported chemists and engineers to develop by Science the various industries. steel, oil, copper, and building materials." To-day an architect must know more than art, he must be a scientist or employ a scientific staff.

One has only to call to mind his travels abroad, his experiences with "lifts" that lifted up but not down, with plumbing without back air-vents, and recall the huge porcelain stoves pointed to with pride as marvels of heating and ventilating apparatus, to realize American building progress. The comforts and conveniences that the American accepts as a matter of course are all very new, very recent, and are not to be found in the most marvellous chateaux of France or the most attractive Venetian palaces. Our model tenements far excel the Doges' Palace in fireproofing, sanitation, comfort, and convenience.

People have been attracted to the larger office buildings, hotels, and apartment-houses, not because they are large or high, so much as because of the superior excellence of their appointments and conveniences and the guarantee of safety from fire which they give. In a large office building or hotel properly designed with the steel frame fireproofed with baked clay, one is safer on an upper floor than in an old style five-story building. Every new improvement is costly at first and is to be found only in the larger buildings where the cost *pro rata* is lessened by the number utilizing it. Thus the larger and higher the building the more up-to-the-minute it will be found to be in catering to the convenience and

* *Building Progress.*

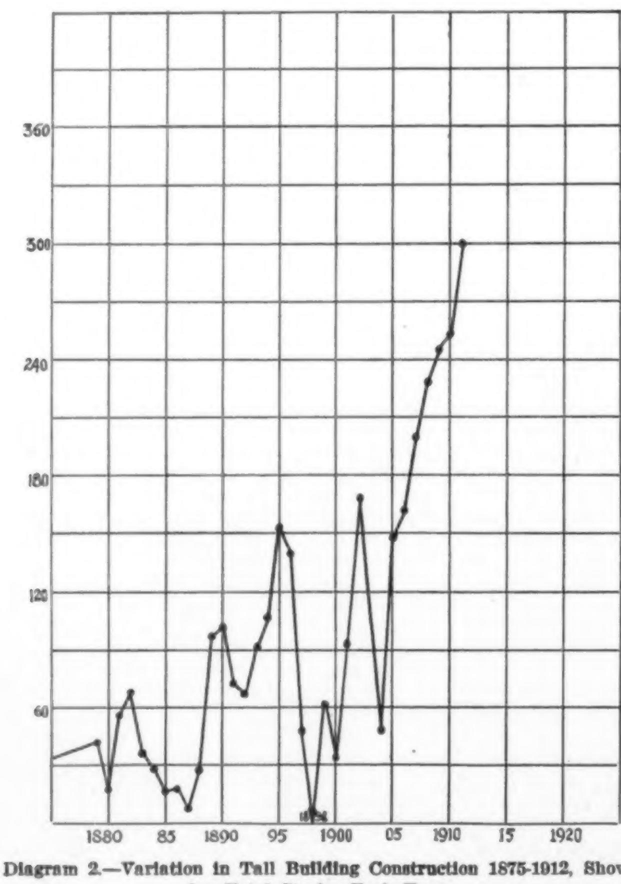


Diagram 2.—Variation in Tall Building Construction 1875-1912, Showing Total Stories Each Year.

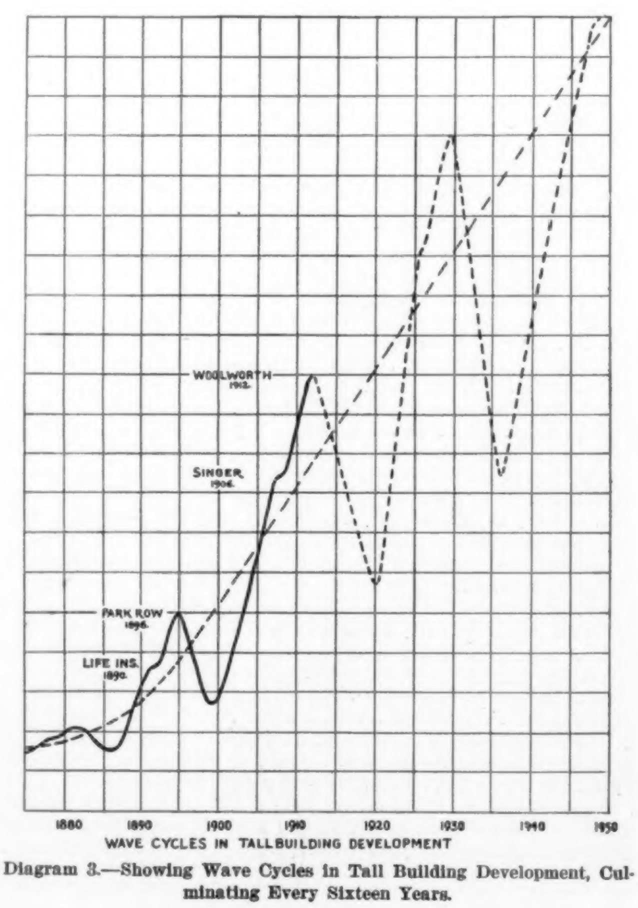


Diagram 3.—Showing Wave Cycles in Tall Building Development, Culminating Every Sixteen Years.

comfort of its tenants. The size and height of a building is therefore an index of its superiority in all respects.

There is here evident a fundamental natural principle—in union there is strength. There is also safety, comfort, convenience, and the superior service and efficiency born of concentration. This explains why buildings tend to be high and also in part why they tend to be higher and higher.

Diagram 1 shows the general trend of tall building in New York from the year 1875, and also gives the tallest structure filed each year in the New York Building Department. While, of course, there is variation, and one year, 1898, the year of the Spanish-American War, during which no tall building was projected, nevertheless, the trend has been steadily toward larger and higher buildings. Probably as a matter of economy of operation, the limit of height is about thirty-two stories, but towers of twice that height, no doubt, will be constructed. There is no engineering drawback to the erection of such a structure or one even higher.

Still, probably no building exceeding fifty or sixty stories will be constructed for some years. While the general trend is upward, a more detailed study of the statistics reveals a curious wave cycle in very high building construction as shown in the diagram. This is probably due to the fact that there is a certain advertising prestige attached to the tallest building in a city, particularly in New York, with the result that there is strong competition for awhile for the height record, and then a lull or period in which no very tall structure is projected. There is also the factor of overproduction and adjustment after a number of tall buildings are completed and available for occupancy. This gives periods of pronounced activity, and more or less depression in very high building construction about sixteen years apart. New York has recently passed through such a period of competition for the highest record in the construction of the Singer Building, the Metropolitan Tower, and the Woolworth Building, and it would seem likely that such a period of culmination will be succeeded by a period of indifference or decline of interest among financiers, engineers, and the general public. Even the engineers who have to do with this point of culmination are dubious; they have strained themselves to exceed the height record of sixteen years ago, and for a new cycle a new, younger ambitious generation must be awaited.

That skyscrapers of more modest height are steadily being built in New York is beyond question. One has but to consult the second diagram showing the total stories in high buildings built year by year in New York. While there are evident in the curve times of lesser activity due to financial uneasiness, nevertheless the high building movement in New York has been steadily maintained and at the present time is culminating in a period of unprecedented activity. Such activity would appear to indicate strongly that such structures are paying investments, for there is apparently no evidence of a falling off in production, even though there are numerous old-style buildings which are not fully occupied. Tenants find it helps business prestige and success to be occupying better office quarters and utilize the latest facilities so that a new tall building soon fills up, drawing the best class of tenants from the antiquated structures about it.

It is but another illustration of the old business principle, "Quality wins." The commercial man having evolved a superior structure to meet his needs, it was not long before its advantages led to the promotion of such buildings for quasi-business interests and ultimately for apartments, hotels, and clubs, and even church activities. In the better-class tall buildings the better light, air and service, and the quiet of the upper floors render them most desirable. They can be made absolutely safe against fire. Indeed nowhere does one seem more secluded and remote from the seething town than in a room in the pinnacle of a skyscraper. Here, strange as it may seem, time, space, and the eternal verities steal into one's thought as one gazes o'er land and sea for sixty or one hundred miles and then look down on the ant-like specks below. The poetry and democracy of the skyscraper we must leave to the poet and commentator of the future, confident that, when our cities are as old as Venice and Florence, our buildings will be one of the wonders of the world and that, the softened record of time forgetting the harshness, the strife of the moment will speak but of the greatness, the glory, the indomitable energy and aspiration of the present hour.

Let the architect who deplores modern conditions but turn the pages of the lives of Michelangelo or Benvenuto Cellini, for examples of the strife and struggle and actual violence and personal danger that attended the practise of art in the glorious times past. An architect is not now set upon with swords and pikes by the henchmen of a rival nor does he often bear to the grave a countenance mashed by an angered competitor as did the great Angelo. It is no longer necessary for an architect to be a military engineer to gain the favor of a prince or be a sturdy man of arms ready to report with armed retainers at the call of his vassal.

And yet it is true as ever that he must be in affairs, not in military affairs, perhaps, or in the street broils of the factions of the town as was the rule in Florence and Venice, but in the larger sense he must be a man of affairs posted on what is going on and on new methods and materials, their merits and possibilites.

The tall building has succeeded thus far on its merits, which is a typical American proposition. Yankee ingenuity has evolved the best building in history. The practical man and the scientist have each contributed his best efforts to its success. The professor has been hailed in his laboratory, called from his calculus. Get us something to do this, stop that, keep down the pressure of the unresting tides, help us weather the tempest's gusts and stand fast against its thrust. Get us an antitoxin for a disease of concrete-steel. Give us better metals.

This century can build taller buildings if called for. America can take from France the prestige of the Tour Eiffel, the tallest structure raised by hand of man, and outdo it in every form and feature. It has but to be called to the test; fresh from the conquest of the Panama Canal where the French, who built the tower, and designed the Liberty Statue in New York harbor, failed ignominiously. Who doubts that the American engineer, successful where the Frenchman failed, can not excel the 300-meter tower of Eiffel?

As for the architecture, the architect must rise to the demands and possibilities of the hour. The dominant Americanism shines forth in many of the older tall buildings despite the drapery of dead forms of the Old World architecture with which they are covered.

Because a sensible Greek or Goth made a thing of beauty out of a waterspout by carving it into a lion's head or a gargoyle, must America forever have copies of these strewn over her buildings? The poverty of imagination and inspiration with which some of our architects have responded to the Gift of Time in the skyscraper is pitiable. Long have they been in learning that art is not something apart, but is the caress of an aspiring imagination to the work of the hour.

In the future the tall buildings will, no doubt, continue to maintain their supremacy in scientific safety and convenience, and when interest revives in the height record, after a period of rest, no doubt they will go higher still in the form of towers. Now that the scientific side of their development is highly perfected, one may naturally expect to see an effort to make them marvels of art as well as of scientific construction.

To achieve this, the architect must give way to the

Pulitzer Building, New York City, Built in 1882.

Woolworth Building, New York City, Built in 1912.

Park Row Building, New York City, Built in 1896.

engineer or must once again gain the common touch, must know processes and products, the vital energies, the laboratory, even the dust of the trades as did Phidias, Angelo, and Leonardo da Vinci.

Then may be expressed the possibilities, the aspiration, the genius of his period, and the transplanted architecture of Europe will appear exotic, and America come into the heritage of Time and of the Ages,—American Art—virile, true, fundamental as the life processes of the Nation, characteristic as the glories of her predecessors in the pageant of history. Then will the tall buildings of the future take place not only among the world's greatest feats of engineering, but become also worthy monuments of the life of their time, become works of art and take rank with the greatest architecture of the past.

On the Appearance of Helium and Neon in Vacuum Tubes*

Critical Comments on the Supposed Synthesis of Matter

By Sir J. J. Thomson

At the last meeting of the Chemical Society,[1] Sir William Ramsay, Prof. Collie, and Mr. Patterson described some experiments which they regard as proving the transmutation of other elements into helium and neon. I have been making experiments of a somewhat similar character for some time, and though the investigation is not yet finished, the results I have obtained up to the present time seem to me in favor of a different explanation from that put forward at the Chemical Society. I described some of these experiments in a lecture at the Royal Institution on January 17th, but as the separate copies of that lecture have not yet been issued, I will give here an account of some of the experiments which seem to me to have the most direct bearing on the phenomenon in question.

I used the method of positive rays to detect the gases; this method is more sensitive than spectrum analysis, and furnishes much more definite information. I may say that the primary object of my experiments was to investigate the origin and properties of a new gas of atomic weight 3, which I shall call X_3, which I discovered by the positive-ray method. This gas, as well as one with an atomic weight 20 (neon?), has appeared sporadically on the photographs taken in the course of the last two years; the discharge in the tube being the ordinary discharge produced by an induction coil through a large bulb furnished with aluminium terminals, and containing gas at a very low pressure. There seems to be no obvious connection between the appearance of either of these lines and the nature of the gas used to fill the tube; the 3 line has appeared when the bulb was filled with hydrogen, with nitrogen, with air, with helium, or with mixtures of hydrogen and oxygen in various proportions; the 20 line when the bulb contained hydrogen, nitrogen, air, hydrochloric acid gas, mixtures of hydrogen and oxygen.

The experiments I made had for their object the discovery of the circumstances which favor the production of X_3, and to test whether it was triatomic hydrogen produced by the discharge, as this is the alternative to its being a new element. I have found that the conditions which lead to a considerable production of X_3 generally give rise to the appearance of helium and neon. Indeed, in the great majority of cases in which I have observed the appearance of traces of helium and neon these gases have been accompanied by larger quantities of X_3; this gas seems to have escaped the notice of the readers of the paper at the Chemical Society. I may mention, too, that along with neon of atomic weight 20 there is a line in these circumstances corresponding to an atomic weight 10 or thereabouts. Though this is probably due to neon with two charges of electricity, it is generally brighter in comparison with the neon line than is usual for the lines corresponding to doubly and singly charged atoms, so that it is not impossible, though perhaps unlikely, that it may be due to a new gas.

The positive rays for the analysis of the gases were produced in a vessel containing gases at a low pressure. I shall call this the testing vessel; the vessel in which the various processes for generating X_3 were tried (the experimenting chamber) was sealed on to the testing vessel, but separated from it by a tap. Thus the pressure in the experimenting chamber was not restricted to being the same as that in the testing vessel, but might have the value which seemed most appropriate for any particular type of experiment. After these experiments were over, the tap was turned and some of the gases from the experimenting chamber let into the testing vessel; a photograph was then taken, and by comparing it with one taken before turning the tap the new gases present in the experiment chamber could be detected. The processes by which I have hitherto got the most plentiful supply of X_3 are:

(1) By bombarding with kathode rays metals and other bodies.

(2) By the discharge from a Wehnelt kathode through a gas at a low pressure.

(3) By an arc discharge in a gas at a comparatively high pressure.

By far the larger number of the experiments were made by bombarding metals, but I will begin by describing an experiment with the arc, as it raises the question of the origin of these lines in a very direct way. An arc between iron wires passed through hydrogen at about 3 centimeters pressure (in this case all the kathode rays would be absorbed quite close to the electrode) for an hour or so, and the gases liberated in the experimenting chamber tested; X_3, helium, and neon were found. The experiment, using the same wires for terminals, was repeated the next day; the three gases were again found. On the next day, still using the same wires, the arc was passed through oxygen; the X_3 line was still there, though much fainter than before; the helium and neon could not be detected with certainty. The next day, using the same terminals, the arc was again passed through oxygen; not one of the lines could be detected. This looks as if these substances were produced by the arc passing through hydrogen. It was found, however, that, still keeping to the same terminals, on pumping the oxygen carefully out and filling up again with hydrogen, the arc through the hydrogen now did not give even a trace of these lines. On replacing the old iron wires by new ones, and sending the arc through the hydrogen, the lines reappeared. This experiment seems to me to point very clearly to the conclusion that these gases were in the terminals to begin with, were removed by the long-continued sparking, and were not produced *de novo* by the arc.

In the experiments when the discharge was produced in a tube with a Wehnelt kathode, the potential difference between the terminals was only 220 volts, so that the kathode rays in the tube had only a fraction of the energy they had when the discharge was produced by an induction coil; X_3 and helium appeared when the discharge passed through this tube. I did not detect any neon.

The method which gave X_3 and also the other gases, in the greatest abundance, was to bombard metals, or indeed almost any substance, with kathode rays. The tube used for this purpose had a curved kathode, which focussed the rays on a table on which the substance to be bombarded was placed. The substance, round the spot struck by the rays, was generally raised to a bright red heat by the bombardment; the bombardment was as a rule continued for five or six hours at a time. I have got the X_3 line, as a rule, accompanied at first by the helium line, and somewhat less frequently by the neon line, when these following substances (which include nearly all I have tried) were bombarded: iron, nickel, oxide of nickel, zinc, copper, various samples of lead, platinum, two meteorites, and a specimen of black mica given me by Sir James Dewar, which was remarkable for the amount of neon it gave off.

The most abundant supply of X_3 came from platinum, and I will describe an experiment with this metal. A piece of platinum foil was bombarded on four days, and the gases produced each day examined. At the end of the first day's bombardment it was found that the line due to X_3 was very strong, those due to helium and neon weaker, but still quite conspicuous. The gases produced the first day were well washed out of the tube, and the foil bombarded for a second day. The gases formed proved to be much the same as on the first day; there was no appreciable diminution. The examination of the result of the third day's bombardment showed that the X_3 line had diminished considerably, the lines due to helium and neon perceptibly. When the gases produced on the fourth day's bombardment were examined it was found that the X_3 and helium had diminished to such an extent that the lines were barely visible. I could not see the neon line at all. In this case the helium was not eliminated until the fourth day. In general I have found that the helium disappeared long before the X_3 gas. Thus a piece of old lead I bombarded gave off appreciable quantities of helium from the first day's bombardment, very little on the second day, and none that I could detect on the third or subsequent days. The X_3, on the other hand, came off in considerable quantities up to the end of the experiment, which lasted for six days. I attribute the superior elimination of X_3 in the case of the platinum foil to the fact that during the whole time the bombardment was concentrated on a patch only about 2 millimeters in diameter, while the lead melted under the bombardment, so that fresh portions were continually being exposed to the rays. A piece of Kahlbaum's chemically pure lead gave appreciable amounts of X_3 and helium, though not nearly so much as the old lead. I tried some lead which had just been precipitated, but could not detect either X_3 or helium.

In the course of the experiments with old lead I let hydrogen into the experimenting chamber to see if it would increase the amount of X_3, but could not detect any effect. On one occasion I let in oxygen when nickel was bombarded, also without any appreciable effect. I think these experiments are in favor of the view that these gases are present in the metal independently of the bombardment, and are liberated by the action of the kathode rays. They are surprisingly firmly held by the metal, and cannot, so far as my experience goes, be got rid of by heating. I kept a piece of lead in a quartz tube boiling in a vacuum for three or four hours, until all but a quarter of the lead had boiled away, and examined the gases given off during this process; neither X_3 nor helium could be detected. I then took the quarter that remained and bombarded it, and got appreciable amounts of X_3 and helium. On a second bombardment the X_3 was visible but the helium had disappeared. As an instance of the way these gases can stick to metals even when in solution or chemical combination, I may mention that though, as I have said, platinum foil after long exposure to kathode rays is freed from these gases, yet I got appreciable quantities of X_3 and helium, though no neon from platinum sponge freshly prepared from platinic chloride.

The reason helium is obtained by heating the glass of old Röntgen-ray bulbs is, I think, that after liberation by the kathode rays, the helium either adheres to the surface or is absorbed in a much looser way than before it was liberated. The question as to how these gases get into the metals is a most interesting one; are they absorbed in the process of manufacture? In this connection it is interesting to note that X_3 does not appear to occur to any appreciable extent in the atmosphere. Sometimes when suffering from the difficulty of clearing out these gases I have been goaded into speculating whether they do not represent the partially abortive attempts of ordinary metals to imitate the behavior of radio-active substance; but whereas in these substances the α particles and the like are emitted with such velocity that they get clear away from the atom, in ordinary metals they have not sufficient energy to get clear, but cling to the outer parts of the atom, and have to be helped by the kathode rays to escape.

I would like to direct attention to the analogy between the effects just described and an everyday experience with discharge tubes—I mean the difficulty of getting these tubes free from hydrogen when the test is made by a sensitive method like that of the positive rays. Though you may heat the glass of the tube to melting point, may dry the gases by liquid air or cooled charcoal, and free the gases you let into the tube as carefully as you will from hydrogen, you will still get the hydrogen lines by the positive-ray method, even when the bulb has been running several hours a day for nearly a year. The only exception is when oxygen is kept continuously running through the tube, and this, I think, is due, not to lack of liberation of hydrogen, but to the oxygen combining with the small quantity of hydrogen liberated, just as it combines with the mercury vapor and causes the disappearance of the mercury lines. I think this production of hydrogen in the tube is quite analogous to the production of X_3, of helium, and of neon. I have been greatly assisted in the experiments I have described by Mr. F. W. Aston, Trinity College, and Mr. E. Everett.

* Reproduced from *Nature*. [1] See this issue, p. 154.

A Simple Demonstration of the Action of Natural Selection*

An Application of Quantitative Tests

By J. Arthur Harris, Carnegie Institution, Washington, D. C.

IN a recent presidential address, an eminent biologist referred to "such highly speculative disciplines as natural selection, Neo-Lamarckianism, neo-vitalism, etc." The criticism of natural selection implied by such association would have been quite in place a few years ago. Since it represents a widely prevailing opinion at the present time, it may not be out of order once more[1] to direct attention to the fact that natural selection is no longer necessarily a "highly speculative discipline," but rather a field for quantitative research. Weight may be given to this statement by a brief description of an experiment made this year at the Station for Experimental Evolution.

Much of the biometric work on selective mortality has necessarily been of a highly statistical character, but this particular experiment has the virtue of extreme simplicity. In the spring of 1912, a series of about 238,000 bean seedlings was examined for morphological variations to serve as a basis for experiments in selection within the "pure line." Of these, about[2] 4,217 abnormal[3] and 5,030 normal[4] seedlings were transplanted to the field. In doing this great care was used to maintain precisely comparable conditions for both normal and abnormal plants. As plants died, from any cause[5] whatever, their labels were brought in and at harvest time a summary was prepared showing the numbers of seedlings failing to develop to fertile maturity.

Of the 5,030 normal plants, 226, or 4.493 per cent died. Of the 4,217 seedlings showing some morphological variation from type, 286, or 6.782 per cent, failed to reach maturity.

Line.	Death Rate of Typical Seedlings.	Death Rate of Atypical Seedlings.
1- 10	4.85	4.98
11- 20	5.16	7.46
21- 30	5.03	7.75
31- 40	4.59	6.49
41- 50	3.81	5.56
51- 60	6.80	8.39
61- 70	5.26	6.94
71- 80	3.30	5.88
81- 90	8.12	9.15
91-100	5.84	11.33
101-110	1.95	2.35
111-120	3.92	7.03
121-130	4.00	7.08
131-140	4.05	9.81
141-150	4.28	5.09
151-160	3.89	2.65

Thus under conditions of careful cultivation, with ample space, with no intra-specific and practically no inter-specific competition, and with a general mortality of less than 5.55 per cent there is a clearly marked selective death rate.

Now if p be the number which perish in a population of m individuals the probable error of that number is given[6] by

$$E_p = 0.67749\sqrt{p \times \left(1 - \frac{p}{m}\right)}$$

From the absolute probable error, the percentage probable error is at once obtained by taking the ratio of 100 p to m. Thus we have for the death rates:

For normals . . . . 4.49 ± 0.20
For abnormals . . . . 6.78 ± 0.26
Difference . . . . 2.29 ± 0.33

Thus the difference is seven times its probable error, and is clearly trustworthy statistically. That it is not due to chance is most strongly brought out by splitting the material up into 16 lots of about ten "pure lines" each, and determining the death rate for normals and abnormals in each lot separately. The little table gives the results.

Because of the low mortality great irregularity is to be expected in the results. *But in fifteen out of the sixteen lots the failure is higher among the abnormal than among the normal plants.*

The material is classified in only the alternative categories, normal and abnormal, or typical and atypical—of which the latter is highly complex, comprising many different morphological variations in their permutations. Possibly, some types among the atypical show a lower mortality than the typical seedlings. When materials are ample I hope to determine approximately the selective value of each of the chief types of variation, both alone and in various combinations. In the meantime, the data given here may serve to record another case of the quantitative demonstration of a selective death rate.

* Reproduced from *Science*.

[1] The progress which has recently been made by biometricians in the investigations of the selective death rate—the mortality which is not random but which is a function of the characteristics of the individual—has been reviewed in a paper, "The Measurement of Natural Selection," appearing in *The Popular Science Monthly*, Vol. 78, pp. 621-638, 1911. Several other studies have been published since the writing of that *résumé*.

[2] The numbers given here are substantially correct, but may be slightly modified when the records are verified by checking against the labels of the individual plants. This cannot conveniently be done until the 8,000 and more individually wrapped plants are opened for shelling and planting in the spring of 1913.

[3] Abnormal includes all morphological deviations from the normal type.

[4] For every abnormal seedling found at least one normal was taken quite at random from the same seed flat. The chief reason for the excess of normals is that in some lines the quintity of seed was not as large as necessary for securing a good number of abnormals, and in these cases normals were planted to avoid losing the line.

[5] An exception is made in the case of a large area of plants which were completely ruined when nearly ripe by obviously non-selective causes outside the experimenter's control.

[6] *Biometrika*, 2: 274, 1903.

Production and Properties of Metallic Films

OPTICALLY plane metallic surfaces are often required for use in philosophical instruments, and a method of producing such surfaces by the distillation of metals *in vacuo* is described by Messrs. Robert Pohl and P. Pringsheim, in the *Ber. Deut. Physikal. Ges.*, 1912. The metal to be distilled is placed in a small cylindrical magnesia crucible, which is heated electrically by passing a suitable current through a sheet of iron or platinium foil in close contact with the outer wall of the cylinder. By distillation in this way satisfactory mirrors of silver, cerium, indium, aluminium, and calcium have been obtained. The method is also recommended for the production of compact sheets of metals which, like beryllium, cannot be obtained in this form by the usual melting process. When aluminium or magnesium surfaces prepared by the above method on cooled sheets of platinium are exposed to the action of light rays in an exhausted tube, the metals are found to exhibit photo-electric activity. In the case of the freshly-prepared surfaces, the emission of electrons is first observed for light having a wave-length between $\lambda = 365$ and $\lambda = 405$ $\mu\mu$, and the emission increases continuously as the wave-length diminishes beyond this limiting value. As time progresses, however, the photo-electric sensitiveness increases, particularly in the region of the longer waved rays, and at the same time the limiting wave length of the photo-electrically active rays moves gradually toward the red end of the spectrum. In the condition of maximum sensitiveness the photo-electric effect can be detected in the case of aluminium up to $\lambda = 700$ $\mu\mu$, and for magnesium up to 1,000 $\mu\mu$. This extension of the active wave-lengths is accompanied by the appearance of a maximum sensitiveness corresponding with $\lambda = 260$ $\mu\mu$.

No evidence was obtainable of any connection between this maximum and the phenomenon of resonance associated with the selective photo-electric effect. After the condition of maximum sensitiveness of the metal surfaces has been reached, which usually requires from six to ten hours, the emissive power remains sensibly constant for several days, and then gradually falls. The decay in emissive power is accompanied by a displacement of the position of maximum sensitiveness toward the ultra-violet end of the spectrum, and at the same time the limiting wave-length of the active light moves in the same direction. This effect is attributed to the gradual escape of gas from the various substances contained in the exhausted tube. If air is admitted while the cell is in a sensitive condition, and the tube again exhausted after a few minutes, the metals are at first almost inactive, but gradually recover the power of emitting electrons when suitably excited.

The work of V. Kohlschütter and his coadjutors upon metallic films has been upon somewhat parallel lines to that just described, and may usefully be considered in conjunction therewith. Starting with the structural modifications of silver, as used for mirrors (*Annalen*, 1912, 387, 86-145), the authors discuss in detail the various factors involved in the deposition of silver as a lustrous adherent deposit by reducing an ammoniacal solution of silver hydroxide with five specific reducing agents. The special conditions necessary for the formation of a satisfactory mirror appear to be that the reduction must proceed mainly or entirely at the surface, and that it must be so conditioned that the product takes the typical coherent mirror form. Differences in the nature of the glass have undoubtedly an effect on the course of the deposition; but this is not an essential consideration, as mirrors may be obtained on metals, india-rubber, porcelain, etc., or even on the free air-surface of the liquid. Traces of various foreign substances produce remarkable effects; thus excess of ammonia or its salts, and of salts of the halogens, will prevent the formation of a mirror, while caustic alkalies in small quantities will help to neutralize the inhibitive effects of the halogens.

The advantage of using small quantities of a copper salt in silvering was recognized by Liebig. Generally speaking, it may be said that conditions which are unfavorable to the production of colloidal silver sols are likely to prevent the silvering process, although the converse is not necessarily true. It is also necessary that the velocity of reduction in the body of the solution should be extremely slow, so that the silver is not acted upon until it reaches the surface. The velocity of reduction is evidently largely dependent on the surface, and particularly on the fact that silver oxide is very readily absorbed. It is further shown that the reducing agent is also adsorbed, and it is this joint surface activity which causes the reaction in these special cases to take place mainly at the surface. It is probable that the special reducing agents, as also traces of salts of copper and lead, give rise to colloidal hydroxides which have a "directing" influence on the form in which the silver is deposited, for each of them has a characteristic effect on the appearance of the deposit. Silver films produced by an electrical discharge in rarefied gases show similar variations with the nature of the gas employed. The above views are supported by experiments on the nature of the mirrors produced. In these the microscope reveals no discontinuities, but the ultramicroscope shows an appearance peculiar to each process, a disperse phase consisting of amorphous silver with characteristic structure.

The same authors have studied the effect of condensing the vapors of arsenic, selenium, cadmium, and zinc *in vacuo*, and in hydrogen, carbon dioxide, nitrogen, and sulphur dioxide at various pressures from 50 millimeters to 700 millimeters. The photomicrographs given in *Zeitschrift für Elektrochemie*, 1912, show that *in vacuo* the metal exhibited a maximum tendency to deposit in the compact form, while an increase in the pressure of any one of the indifferent gases showed a tendency to decrease the size of the deposited particles, and to increase the number in a given area. At the same pressure the dispersive effect was greatest for the denser gases. This effect is probably accounted for by the effect of the gaseous atmosphere on the Brownian movement of the suspended particles, the more concentrated the gas the greater being the resistance to the cohesive forces which tend to a reduction in the volume of a given mass of deposit.

Continuing their investigations into finely divided metals, they have examined into the pulverization of a silver cathode during the passage of a discharge through hydrogen, nitrogen, or argon at low pressures. The thin layers of metal produced were examined microscopically, and also for their conductivity and variation of the latter with time. The amount of metal required to produce a given conductivity is greater in hydrogen than in nitrogen, and greater in nitrogen than in argon. The metallic deposits undergo a rapid spontaneous change of resistance, the mode of progress of this change being a characteristic of the gas used in the discharge-tube. The finest subdivision is produced in argon, the largest particles being formed in hydrogen, and in time the deposits become more transparent, owing to the formation of large particles. The cause of these changes is a kind of sintering process in the silver, which tends to produce a denser deposit; but where the quantity of metal is small the layer may be broken. The spontaneous change in resistance can be greatly delayed by increased gas pressure, so that the gas may be looked upon as a dispersion medium for the metal. At 100 deg. Cent. the deposited silver is oxidized by the atmosphere, the most rapid attack being that on the finest deposits—namely, those produced in argon.—*Engineering.*

A Cross Between a Leopard and a Lion

A NUMBER of years ago, Hagenbeck's, the celebrated animal merchants of Hamburg, obtained a litter of hybrid cubs, half lion and half tiger. We read in *La Nature* that a similar case is now on record, in which a lioness threw a litter of two cubs to a leopard. One of these cubs died at the age of 21 months, the other is still living, and is now two years old.

Where the Tunnel will end and the Canal Begin.

Blasting the Rock for the Railroad to the Dam Site.

A Great "Pacific Service" Project*

The South Yuba and Bear River Hydro-Electric Development

By James H. Wise

In these pages the writer will outline briefly the hydro-electric project on the south fork of the Yuba and Bear rivers, which has been in contemplation for some time, but on which active work was not begun until permission was received from the Railroad Commission on July 3rd.

The development makes use, for power purposes, of the water already impounded in twenty reservoirs in the catchment area of the South Yuba, having a capacity of 2,024,000,000 cubic feet, combined with additional storage of 4,000,000,000 cubic feet, to be secured at Lake Spaulding. The water thus stored is to be diverted, together with the natural run-off, to the Bear River water shed, conducting it in tunnels and canals along the south side of the Bear River Canyon to a point about three miles northeast of Towle Station on the Southern Pacific, to a regulating reservoir known as the "Drum Forebay." Two riveted steel pipe lines will lead from this reservoir to the power house 1,350 feet lower in elevation, and situated on Bear River, where an installation of 40,000 kilowatts, consisting of four units, will be erected, together with the necessary transformers, exciters, governors, and other adequate equipment to make the entire installation complete. Electric power from this plant will be transmitted at 115,000 volts on a double circuit steel tower line, extending in a southwesterly direction via Nicolaus to Cordelia, the load center of the company engaged in this development. At this point step-down transformers will be used for reducing the pressure to approximately 60,000 volts, permitting the power thus to be transmitted to various parts of the system: Oakland, Berkeley, Alameda, San Rafael, Santa Rosa, Vallejo, Petaluma, and northward toward Suisun, Cement, Woodland, Sacramento, Davis, Dixon, and, in fact, to any part of the vast territory already covered by the 60,000-volt network of transmission lines.

* Reproduced from the *Pacific Gas and Electric Magazine*.

Showing Where the Great Dam will Stop the Waters of the Yuba River.

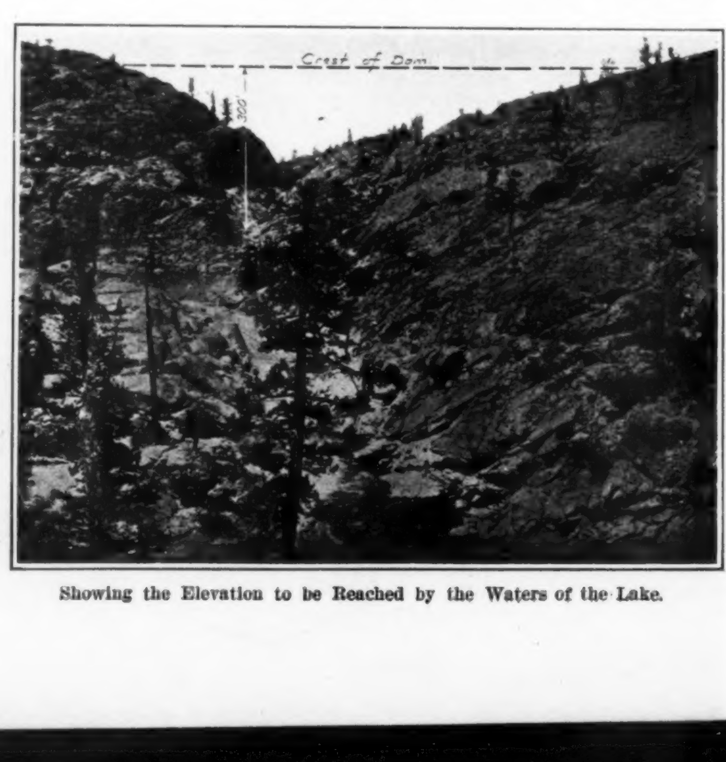
Attention is called to the buttresses of rock on either side against which the concrete structure, 300 feet high, will rest. It will be the greatest dam of its kind in the world.

The project further includes the construction of a steel tower line from Cordelia to San Rafael, Sausalito and Lime Point, thus providing Pacific Service to the Marin peninsula and the transmission of hydro-electric power ultimately to San Francisco.

Adverting to Lake Spaulding, this splendid reservoir site, with a capacity of 4,000,000,000 cubic feet, or nearly double the combined capacity of all of the reservoirs in the South Yuba system, will be formed by the construction of a huge monolith of cyclopean concrete. The dam will be of a gravity type section, arched upstream for an additional factor of safety and a more substantial type of construction, thus insuring stability and absolute security against any possible failure. The dam will be 300 feet in height and will be built somewhat similar to the New Croton and Croton Falls dams of the New York Water Supply, and of cross section, approximating the Roosevelt Dam, which impounds such a vast quantity of water for the Salt River project, a part of the reclamation work of the United States Government. The reservoir is situated about two miles northeast of Smart Station, on the Southern Pacific Railroad, at an elevation of 4,600 feet. The proximity o' the site to the main line of the Southern Pacific is indeed fortunate and a spur track directly to the location of the dam will greatly facilitate and economize the work. This track has already been constructed and work on the cableways, sand and gravel bunkers and tunnel outlet is now rapidly progressing.

In connection with this work at Lake Spaulding, not the least important is the operation of the old Birce & Smart sawmill, now owned by the company which is carrying out the project. The high dam will flood 700

Looking Toward the Dam Site from up Stream.



Showing the Elevation to be Reached by the Waters of the Lake.

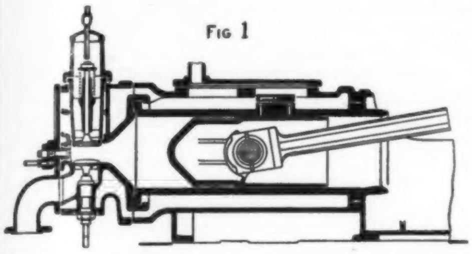
acres of land which now contains over 1,000,000 board feet of standing timber, which the mill has been converting into ties, boards and dimension stuff at the rate of from twenty to thirty thousand board feet of lumber per day. There is already a good stock of lumber on hand for the work as it progresses. The clearing of the reservoir site will therefore be practically completed and, at the same time, a most valuable use of the timber will be made. Any surplus will be used in the maintenance and repairs of the many flumes on the South Yuba system. A solid rock concrete-lined tunnel, 4,427 feet long, will form the reservoir outlet and will conduct the water to the upper end of a concrete-lined canal 8½ miles in length, having a capacity of 400 second feet, or 16,000 miner's inches. This canal will contain no flumes but will have a short syphon near the lower end leading to the forebay previously mentioned. The regulating reservoir site is a large area capable of being converted into a forebay of 400-acre feet capacity without excessive cost, and will thus provide sufficient water to run the entire plant for 24 hours, and will amply provide for peak load and other power fluctuations—a most valuable adjunct to a plant of this size and importance.

The forebay will be constructed by excavating the earth and loose material from the basin, forming a dam about 35 feet in height on the south or lower side of the slope. The earth embankment will be made according to the most approved methods, namely, by placing the material in thin layers, thoroughly dampening, rolling and compacting, thus making the dam absolutely impervious. Two riveted steel pipe lines leading from this regulating reservoir will be 6,300 feet long and 72 inches in diameter at the upper end. The lower end will be provided with "Y" branches, castings and suitable gates and nozzles for conducting the water to the 8 water wheels, each with a capacity of 9,000 horse-power. The pressure at the nozzle of the 7-inch stream impinging upon the water-wheel buckets will be 585 pounds per square inch, or nearly three times the high-steam pressure used by the big locomotives of the Southern Pacific Company. It is hoped that the work on the project will be completed toward the end of the current year.

A Crude Oil Diesel Engine

Special Design for Horizontal Type

In designing a horizontal type crude-oil engine working on the Diesel principle, the conditions are appreciably different from those in the customary vertical type engine operating on the same fuel. In order to secure a simple shape of combustion chamber and a reliable and



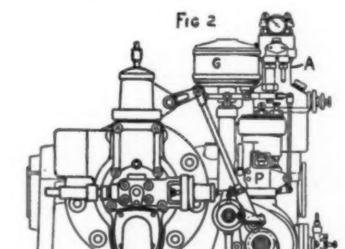
Longitudinal Sectional View of Cylinder and Head.

economical method of fuel injection, the most advantageous arrangement of the fuel-feeding device and its actuating mechanism, such as the cam shaft and levers, must be given careful consideration. These important and desirable advantages have been obtained in the design of a crude oil engine of standard make by placing the fuel needle valve so that it can be conveniently actuated from the cam shaft running parallel with the axis of the cylinder, involving only the use of a cam and a simple two-arm lever. The injection of the fuel in a direction parallel with the cylinder bore is accomplished by having a right-angle bend in the fuel port between the needle valve and the sprayer through which the fuel is injected into the compressed air in the clearance space.

The accompanying illustrations show the details of this design, Fig. 1 being a longitudinal sectional view of the cylinder and cylinder head Fig. 2 an end view of the cylinder head and valve mechanism, and Fig. 3 a diagrammatical illustration of the fuel-feeding device.

Referring to Fig. 3, the fuel inlet port leading to the sprayer is controlled by the needle valve in such a manner that this valve, when seated in its casing, simultaneously closes the connecting port *b* through which the fuel pump *p* delivers the oil. The pump must discharge fuel only when the needle valve *n* is open, so that during starting, while compressed air only is admitted to the combustion chamber, the fuel pump is temporarily disconnected by a handle which serves to remove a pin provided for this purpose.

A suitably formed cam, controlled by the governor *G*, Fig. 2, actuates the fuel pump in such a manner that the amount of fuel delivered by the pump is distributed between the fuel port leading to the sprayer and a by-pass connection which allows a portion of the fuel to be returned to the tank, the volumes of oil distributed in this way being in accordance with the load carried by the engine. When operating under a light load, the by-pass is opened to a greater degree, and *vice versa.*



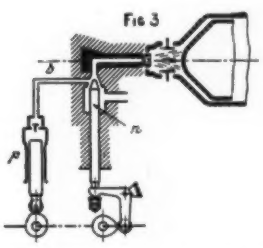
End View of Cylinder Head and Valve Mechanism.

During the first part of the injection period, the air carries with it a certain amount of fuel, which has the effect of making ignition more certain. This is accomplished by the fact that the fuel pump is arranged so that at the beginning of its discharge stroke, aided possibly by the elasticity of the pipe connections, it delivers a slightly larger amount of fuel than during the end of the stroke, resulting in a slight rise in pressure at the beginning of the combustion period. In this respect the engine differs from the regular Diesel type, in which the combustion pressure does not exceed the compression pressure. The comparatively small increase in pressure is not, however, objectionable, especially in engines of smaller sizes.

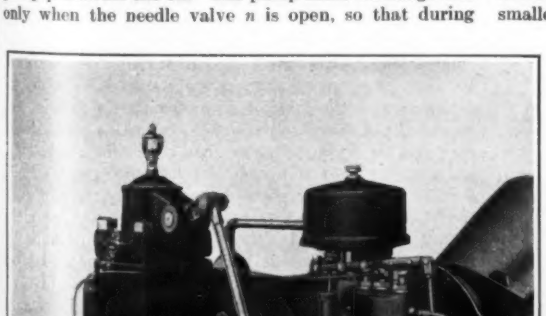
The engine possesses the further advantage of being started with compressed air at low pressure, 180 to 200 pounds per square inch, the safety valve on the air receiver being set at 200 pounds. This is an important feature in engines used for general power purposes, in that it dispenses with air receivers specially designed for storing highly compressed air. The method of starting with low-pressure air makes it possible to admit a full charge of air through the starting valve, and it also gives a greater degree of flexibility in the starting period, making the engine less sensitive in this respect, as compared with engines which are started with air under high pressure through a comparatively small valve.

It is desirable to have high-pressure air available for the injection of the fuel as soon as possible, in fact immediately after the beginning of the starting process. To accomplish this, air from the receiver, while admitted at 180 to 200 pounds pressure to the engine cylinder, simultaneously enters the space in the air compressor *a*, Fig. 2, between the low- and high-pressure stages. Therefore the compressor, while operating in its regular manner, delivers highly compressed air direct to the fuel needle valve during its first stroke in the high-pressure stage, without employing a high-pressure receiver between the compressor and the needle valve.

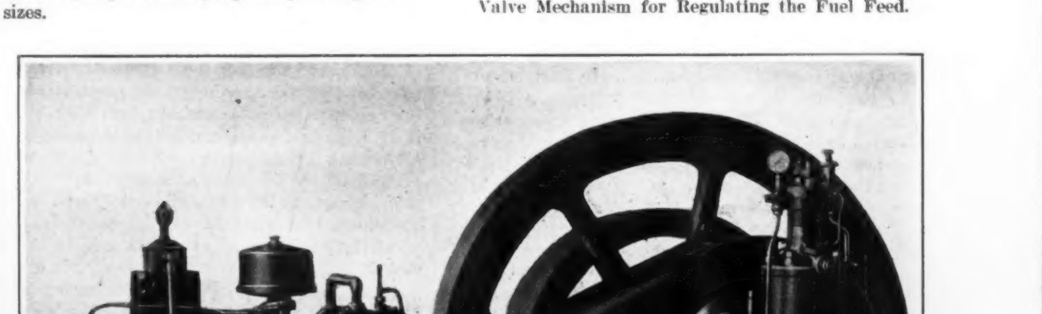
Eliminating this receiver also results in an automatic regulation of the injection pressure relative to the load conditions. While the volume of air for injection purposes is practically the same under all loads, the pressure at which this air is delivered varies, it being lower when less fuel is admitted, because the resistance in the



Valve Mechanism for Regulating the Fuel Feed.



View Showing Cylinder Head and Valve Mechanism.



General View of the Engine as Seen from the Side.

injection ports is diminished on account of the decrease in the volume of the fuel passing through these ports. This feature has been clearly demonstrated when during a recent test on a 35 horse-power engine of this type careful readings were taken which showed that the injection pressure varied, under changing loads, between 750 and 940 pounds per square inch. An air meter inserted in the pipe line recorded a practically constant volume of air used under these conditions, namely 192 cubic feet per hour at full load, 197 cubic feet at half load, and 200 cubic feet when running idle.

The compression pressure in this engine was 440 pounds per square inch, temperature about 1,100 deg. Fahr. Under varying loads, the temperature of the compressed air, influenced by the temperature of the cylinder walls, cooling water and outside air, was subject to slight changes, but was always 15 to 20 per cent above the ignition temperature of the heaviest oils.

The Birth of the Atom*

Has Matter Been Synthesised

The Chemical Society, meeting on February 6th, at its rooms in Burlington House, opened its Proceedings by considering two remarkable papers, the first by Sir William Ramsay on the presence of helium in an X-ray bulb, and the second by Prof. Norman Collie, of University College, London, and Mr. H. Patterson, of the University of Leeds, and late of University College. Briefly the papers may be described as a notable contribution to the newer school of physics, and the conclusion to be drawn from them is that the authors claim to have done one of two things, either to have achieved clearly and definitely the transmutation of elements or to have evolved matter from energy. At the outset it must be admitted that neither of these claims was put forward in so many words by the authors, but to appreciate the significance of their discovery, of which a full account is given below, it may be well to get a clear idea of current chemical conceptions, both as regards the transmutation of elements and the relation existing between matter and energy.

ESSENTIAL OF THE ATOMIC THEORY.

The essential of the atomic theory from the point of view of transmutation was till quite recently that every object known in Nature was either elementary or was built up of a combination of two or more elementary substances. Thus oxygen, hydrogen, carbon were looked upon as elements, because, among other reasons, by no known means could they be split up into anything simpler. Sugar, on the other hand, was regarded as a compound because the chemist is able to break it down into carbon, oxygen, and hydrogen. The instance is a simple one to be verified by the homeliest of apparatus. It is only necessary to heat a lump of sugar. The black mass left over is carbon, and if a cold surface such as a piece of glass is held above the sugar, water, which is a compound of hydrogen and oxygen, can be seen to condense on the surface. Before the atomic theory was formulated it was the dream of the alchemist to transmute the baser into the nobler metals, to turn iron, for instance, into gold, but with the acceptance of the atomic theory the idea was dismissed as unthinkable because the different atoms were looked upon as utterly separate individuals, having no connection one with another—as being, in fact, the final units of which matter was built up. Passing over the suggestive grouping of the atoms by Newlands, Mendeléeff, and others in the fifties, and the brilliant hypotheses that led men to think that the atoms themselves were universes built up of infinitely complex groupings, one comes to the opening years of the present century, when it was established, first, that radium was an element, and, second, that it was degenerating spontaneously into helium and radium emanation. The credit of the discovery belongs to Sir William Ramsay and Mr. Frederick Soddy, and with it followed a whole host of other transmutations, all of them spontaneous, none of them able to be hastened or retarded. In 1906, however, in a remarkable paper by Mr. Cameron and Sir William Ramsay, the view was put forward that if copper were subjected to the action of radium emanation the element copper could be to some extent broken down into the element lithium. A pictorial analogy can now be made to represent the meaning of transmutation. We may imagine the elements classified into eight groups, having such geometric forms as triangles, squares, pentagons, hexagons, and so forth. There would be some eight triangles, some eight squares, some eight pentagons, and so on, all increasing by progressive stages and built up like the Indian boxes which fitted one within the other. The large box containing all the others behaves as a separate unit, completely hiding the boxes within. Then comes a particle shot out with inconceivable velocity by radium, and shatters the outer box, leaving behind it the remaining boxes intact. The eight-box element has been transmuted into the seven-box element, just as the seven-box element, if its outer case be shattered, into the six-box, and so on down the series. It is a part of elementary chemistry that copper, sodium, and lithium are all elements belonging to a single grouping.

MATTER AND ENERGY.

To turn now from transmutation to the concepts of matter and energy. It may be regarded as still being the orthodox view that both matter and energy are indestructible, and that neither can be turned into the other. When coal burns and gives birth to energy the coal is not lost but re-appears as the gas carbon dioxide, the energy obtained being what chemists term the energy of chemical combination, or put more popularly, in the specific instance, the recovery of the energy of the sun's rays that were absorbed by the primeval forests, and trapped and preserved when these were compressed into the coal measures. The newer school, however, of which M. Gustave Le Bon is one of the leading exponents, holds that energy and matter are one, that the mysterious ether of the universe appears to our senses as matter when once it is stirred into vortex rings, that the birth of a star is nothing more than the ether set into violent ordered motion, acquiring the properties of matter, much as a smoke ring by virtue of its movement takes on some of the properties of a solid substance. In this view the atom would consist of many thousands of particles, each particle being ether in a whirl and the whole held together by a supreme force. With this as an introduction the experiments described last night come into proper perspective. The authors show that if they send an electric discharge—that obtained as in the cathode rays from an ordinary Ruhmkorff coil—through a vacuum tube containing a little hydrogen, helium and neon make their appearance. This happens in each occasion, regularly, in a short space of time. The gases were not present at the outset of the experiment, the possibility of their being introduced from outside has been rigidly excluded, but two well-known elements have made their appearance as the result of the passage of an electric discharge through a vacuum tube containing hydrogen.

TWO POSSIBILITIES.

Two possibilities present themselves, and it will be for future experiments to determine which is the correct hypothesis. Either the hydrogen or the elements contained in the glass or in the electrodes have been transmuted into helium and neon, or as a result of the energy of the electric discharge, helium and neon, two elementary material gases, have been created out of immaterial ether.

A final point before the report. Last night's experiments are notably different from the previous ones of Sir William Ramsay. His early discovery of transmutation that radium broke down into helium, and niton or radium emanation, was an instance of the disruption of the most complex element known, and was in so far comparable with the breaking of a wave when it reaches beyond its critical size. His later experiments were so difficult of reproduction that in his book published this year Prof. Rutherford regards the results as non-proven, Madame Curie and her fellow-workers having attempted to reproduce the phenomenon and failed. Prof. Collie and Mr. Patterson have either transmuted ordinary simple elements into neon and helium or they have created out of the ether elements of extreme simplicity. It is a matter of indifference whether these elements have been built up from the hydrogen in the tube or whether they are built up directly from electrical energy. The point is that if the hypothesis suggested is true the complete life history of the different atoms has been determined experimentally. In the hottest and most recently-formed stars, hydrogen, helium, and possibly one or two other elements not known on the earth, make their appearance, all of them being of small atomic weight. As the stars cool down the atoms become heavier, or in other words, you get the synthesis of atoms. There is some process at work building up the atom that till now has never been realized experimentally, but in the experiments described last night one is apparently assisting at the birth of the atom. The other end of the history, the death of the atom, has already been told in the overloading and disruption of the radium atom, and in consequence the initial and the final episodes in the life history of the atom have, it is thought by many, been experimentally described. Much of the history, it should be added in conclusion, is hypothetical, but there is good reason to believe that the experimental facts reported last night are closely related to the hypothesis.

SUGGESTED ORIGIN OF NEON.

In the absence of the President of the Chemical Society[1], Prof. Arthur Smithells, Professor of Chemistry at the University of Leeds, presided at the meeting of the Chemical Society at Burlington House on February 6th.

Sir William Ramsay, in his paper on "The Presence of Helium in the Gas from the Interior of an X-ray Tube," reminded the Fellows that some years ago he and Mr. Cameron had obtained lithium from copper, though people were mildly incredulous. (Laughter.) He had also published a statement to the effect that under the influence of radium emanation silicon gave some carbon dioxide, while with thorium a respectable quantity of carbon dioxide was obtained, the inference being that the element tended to break down to carbon, which in the presence of oxygen became carbon dioxide. When the time came for him to have to return the radium that had been lent to him he had looked about for some other substance with which to continue his experiments. Radium gave helium and niton, or radium emanation, and also heat and α-rays. Niton was extraordinarily energetic, more so than any other known substance, so that a cubic centimeter of it gave more than three and a half million times the energy of a cubic centimeter of explosive gas. During the decomposition of the emanation α-rays were given off and β-rays with even greater velocity. The question to determine was whether it was possible to find signs of chemical transformation through the β-rays, a difficult one when it was remembered that only 6 per cent of the energy of emanation appeared in the form of β-rays. He had made the attempt, however, with old X-ray bulbs. In the first instance his method had been to break the bulbs, and on analyzing the gases contained in the glass by means of the combustion tube, he had found traces of helium, neon, and argon. Last November, instead of breaking the bulbs, he had heated them to 300 degrees and collected the gases, finding the spectrum of helium and also a small quantity of neon. As a result of these experiments there was no question that the bulbs contained helium. The problem was what was the source of this helium. It might have been derived from the electrodes, or from impact with the cathode or anti-cathode, or from the impact of the cathodic rays with the glass. Last summer he had informed the Society that on treating water with radium emanation, instead of getting helium, neon was got, the equation suggesting itself that helium (4) plus oxygen (16) equals neon (20). Thus at Bath, when the waters were charged with radium, great quantities of both neon and helium were produced.

RESULTS REACHED INDEPENDENTLY.

Prof. J. Norman Collie and Mr. H. Patterson read their paper on "The Presence of Neon in Hydrogen after the Passage of the Electric Discharge through Hydrogen at Low Pressures."

Prof. Collie drew attention to the fact that he and Mr. Patterson had done the early portion of the work of their joint paper independently and from different points of view, and that it was only in the later stages of the work, when they learnt that they were getting the same results independently, that they had collaborated. He described his early experiments, which had been undertaken on fluorspar with the hope of decomposing the fluorine by means of the electric discharge. On testing some fluorspar that Sir William Ramsay had received from Iceland last summer he had found that helium was given off. Further investigation showed that the spar gave off carbon monoxide and other gases, and when the problem had been investigated with one of Sir William Ramsay's ingenious apparatuses it had been determined that on treating the spar neon was produced. Further investigation showed that the same result was obtained by using calcium chloride, and again by using glass-wool, and then again by carrying out the discharge on the bare glass-tube. (Cheers). What was the origin of the neon? Had air leaked in through the taps of the apparatus? Was it due to impurities in the hydrogen placed in the tube to conduct the current, or to the oxygen used in the later stages to get rid of the hydrogen, or to neon being dissolved in the glass? Prof. Collie described the experiments undertaken to exclude the possibility of there being any such origin for the gas, and also the attempt made with a negative result to see whether the neon could have leaked through the heated glass-tube.

STANDPOINT OF PURE PHYSICS.

At this stage, Mr. Patterson continued the paper, showing the point of view from which he had undertaken the research. He had been interested, he said, in the pure physics of the electron. He described the formulæ on which he had built up a hypothesis, and startled the Fellows by the calm announcement that he had thought

* Account of the proceedings of the Chemical Society reproduced from the London *Morning Post* of February 7th.

[1] An important comment on the papers here presented will be found on p. 150 of this issue.

it conceivable that by doubling the electrical charge on the hydrogen atom it might be possible to convert this into an α-particle, and so into helium. He did not, he said, regard the result of the experiment as proving the hypothesis, but he thought that perhaps his hypothesis provided an explanation. (Cheers).

Prof. Collie then resumed his reading of the paper, drawing attention to the fact that Mr. Patterson, in sparking the hydrogen, had not got helium, but neon. He had, he said, criticised Mr. Patterson's method of preparing hydrogen, and to avoid this possibility of error, Mr. Patterson had started by filling his apparatus with pure oxygen, but on pumping this out had got the same result. Another possibility had then suggested itself. While neon did not enter glass under ordinary conditions, might it not do so under the influence of the X-ray discharge? To make certain on this point the experiment tube was surrounded with another tube containing neon, and about the same result was obtained as with ordinary air. A similar experiment was made with helium with negative results. Lastly, before sending in his paper the previous week, he had used the outside vessel as a vacuum (a higher than an X-ray vacuum), and still the neon appeared, the quantity thus obtained being comparable with that present in about 2 cubic centimeters of air. (Loud cheers).

STARTLING DISCOVERY.

Last Friday and Saturday, he repeated, he had performed the experiment twice with the experiment tube surrounded by a vacuum. He had then asked himself whether there was anything else he could test. He had nothing particular to do that afternoon, and had decided to test whether there was anything in the outer chamber. He let a cubic centimeter of pure oxygen into the outer chamber, and he obtained a slight explosion due to hydrogen. He absorbed the oxygen in the usual way with carbon, but there was still some left, which he regarded as rather a nuisance. He repeated the process of absorption, but the gas still remained, in relatively large amount. He decided to test it, and turned on the coil. The sight he then saw astounded him, for the tube was a blaze of helium, with some neon mixed. (Loud cheers). He communicated with Mr. Patterson, who repeated the experiment. Mr. Patterson at first found helium. Then he put oxygen into the outer tube, and he found, instead of helium, a large quantity of neon, the equation being suggested that helium (4) plus oxygen (16) equals neon (20). (Cheers). If the helium had sufficient velocity, when produced in the inner tube, to traverse it, it was quite possible for a new element to be produced. For his own part he was quite satisfied provided neon and helium had been produced from substances in which they were previously not present. (Cheers).

POSSIBLE ORIGIN OF THE GASES.

There were various possibilities. It might be that the elements of the tube in the electrodes gave neon or helium under the influence of the discharge. This gave them ten or a dozen elements to choose from as the source. Again, there was the chance that the hydrogen was the source. Or it was possible that they were dealing with a primordial form of matter, the primordial atom which, when produced, had all the energy necessary for forming the world. By the combination of these "atoms" the atoms of the elements would be found. Helium, and possibly hydrogen, were present in the nebular state, and they were present in the experimental tube. Possibly the electric current directed the flow of these atoms with the full force of its energy, and with the phenomena of heat and light the elements came into existence. At any rate one thing seemed certain. The elements could be changed, and they could be changed in a way very different from the way that radium was changed. In its case the process could neither be hastened nor retarded. But the present phenomenon was artificial, and, further, the process was occurring at the other end of the system of the atoms, producing elements of low atomic weight. The old idea of the transmutation of elements had to be altered. We were coming to know more of sub-atomic matter, and it had to be generally realized that—

The old order changeth, yielding place to new,
And God fulfils Himself in many ways
Lest one good custom should corrupt the world.

Prof. Collie then showed two beautiful illustrations of the effect of sparking neon, the gas when absolutely pure blazing out into a pillar of perfect flame red. He added, in conclusion, that he had broken the experiment tube, heated it, and found under the microscope that it was full of bubbles of gas that had been caught in their passage through the tube.

A MOMENTOUS PAPER.

Prof. Smithells opened the discussion by saying that he was somewhat breathless at the papers they had heard. It required a great deal of courage for scientific workers to bring forward such results, and they must admire it. Their courage, he thought, was justified, for their experimental record was such as to justify what in others would have been extremely rash. He paid a generous tribute to the care and patience with which Mr. Patterson had conducted the experiments in his laboratory at Leeds. Of the work of Prof. Collie and Sir William Ramsay it was unnecessary to say anything. For dramatic interest, he thought, the paper had never been surpassed. The obvious criticism was that in the work enormous weight had necessarily been laid on spectroscopic evidence, and his limited experience in this connection had taught him caution, but he felt sure that the authors were too experienced to fall into such pitfalls.

Sir William Ramsay expressed his great gratification at other researchers having taken up the investigation. With radium there had been no chance to repetition, but the present experiments on transmutation could be reproduced by anyone with a coil and a battery. He was extremely gratified that the theory of transmutation now no longer rested on his *ipsissma verba*.

Prof. Smithells moved that the thanks of the Society be given to the authors, to whom they felt a great obligation, for their momentous communication.

The Lick Observatory*

Its Contribution to the Progress of Astronomy

The particular universe of stars in which we dwell is half again as large in scale as the world has been supposing. Our own sun is still youthful, and keeps traveling northwardly through space at the comparatively leisurely pace of twelve miles per second, or only two thirds the average speed of stars of its own class. The North Star is not really a single star, but triple, consisting of three suns revolving about a common center.

These are some of the recent discoveries of the Lick Observatory, the famous graduate astronomical department of the University of California.

People who learned their astronomy twenty years ago, or five years ago, will have to change many of their ideas of the universe in the light of the Lick Observatory's newly achieved knowledge as to how the heavenly bodies are born and live and die. Nowhere in the world is so much being done to alter and expand man's knowledge of the stellar universe as on Mount Hamilton, under the direction of Dr. W. W. Campbell, the famous Director of the Lick Observatory.

When Dr. Campbell first came to the Lick Observatory, comparatively few double stars were known. He turned the great 36-inch telescope, then the largest in the world, upon this problem, and, in the years since then, the Lick Observatory has discovered over 4,000 double stars. By the eye at the telescope it was proved that one out of eighteen stars, on the average, is double.

But next the Lick Observatory proved that vast numbers of stars which, even to the most powerful telescopes look like one, are really double, or even triple or quaruple. Work with the spectroscope showed that at least one star in every four is double. The first magnitude star Capella, for instance, consists of two stars nearly equal in brightness, which revolve around their common center of mass every 104 days.

ONLY 15,000 NEBULÆ OBSERVED.

Only some 15,000 nebulæ have been observed as yet, but the Lick Observatory has proved that several hundred thousand nebulæ visible to the telescope or the camera exist in the sky, waiting to be discovered whenever opportunity can be found to undertake the work. Most nebulæ have a spiral form.

Three extra moons have been found for Jupiter by the Lick Observatory, the planet's sixth, seventh, and eighth satellites having been discovered in 1892, 1904, and 1905.

Some thirty comets have been discovered by the Lick Observatory.

It has been shown that the principal "New Stars," which now and then blaze up in the heavens, only to fade dim afterward, have been converted into nebulæ, and that the nebular stage passes later, in the course of many years, to the ordinary stellar condition.

Total eclipses of the sun have been observed by expeditions sent by the Lick Observatory to many parts of the world—to French Guiana, for instance; to Northern California, to Chili, India, Georgia, Sumatra, Spain, and Egypt, and to the South Pacific. The Hearst Expedition to Chili in 1893 and the Crocker Expedition to India in 1898 recorded for the first time the wonderful structure of the inner solar corona, and the numerous expeditions sent out by the generosity of Regent William H. Crocker have established that the light of the inner coronal structure is largely inherent, whereas the light of the outer parts of the corona is largely reflected sunlight.

One of the greatest contributions to cosmology that the Lick Observatory has made is Director Campbell's proof by spectrographic observations that stars in the earlier stages of their existence are traveling slowly through space, and that their speeds increase as they grow older. This hastening of pace as suns increase in age is highly important in interpretations of the life of the universe.

PROBLEMS OF ASTRONOMERS.

Among the problems which the astronomers of the Lick Observatory keep always before them, in their task of pushing forward the frontiers of human knowledge, are these: What is the form and what are the dimensions of the space occupied by our stellar system? How are the individual members of the system distributed throughout that space? What are the relations of the stars, planets, moons, nebulæ, comets, and meteors to each other, both as classes and as individuals? In accordance with what laws have these bodies been evolved from materials in earlier stages of existence? What has been the history of the celestial bodies? What are their present physical conditions? What has the future in store for them?

Besides the great station on Mount Hamilton, the University has an outpost of the Lick Observatory in South America. This is the D. O. Mills Observatory, supported by the generosity of Ogden Mills. It is on the summit of Cerro San Cristobal, 900 feet above the city of Santiago, Chili. Its 37-inch reflecting telescope and spectographs are devoted primarily to studies of the motions of the fainter stars, to aid in understanding the motion of the solar system and the structure of the stellar universe.

The Lick Observatory itself has a most favorable situation. Its altitude is 4,209 feet. Over 6,000 people see the great telescope every year, nine tenths of them making by automobile the journey from San Jose over twenty-nine miles of beautiful mountain roads. Visitors are welcome daily, until sundown, and every Saturday evening people who arrive before nine o'clock are permitted to look through the huge Lick Telescope, and thus to see some of the brilliant marvels of the heavens, such as the Great Nebula in Orion, or gorgeous Jupiter and its moons, or the brilliant star-cluster in Hercules, where 5,000 visible stars are shining in one-two-millionth of the area of the sky, and each of these suns probably as far from each of its nearest fellows as we are from the nearest fixed star—and that is so far that it takes light four years to cross the gulf—four years, with the star-beam traveling 186,000 miles every second.

* From the New York *Evening Post*.

Diet Deficiency and Disease in Live Stock

In a paper read by F. A. Place before the Australasian Association for the Advancement of Science, the speaker explained that the connection between deficiency in certain food elements and disease in livestock had occupied his attention in England, India, Burma and Australia, where the class of disease is known under various local names as "dry bible," impaction, Coasting, Midland and Bush sicknesss and corresponds in many ways to the South African Lam and stieffziekte. But in all these countries there is a lack of accurate knowledge of the cause, though veterinarians treat the forms of disease with a certain amount of success in an empirical way by giving bone meal licks, yeast and similar remedies. The similarity between the main symptoms of these diseases and human beri beri and scurvy led Mr. Place to compare the literature of the human and animal diseases. This revealed the want of analyses of common Australian fodders, a want that is being remedied by observations at the South Australian Government Agricultural College at Roseworthy; while the failure of rations based solely on chemical analysis has clearly demonstrated a deeper cause for the trouble and at the same time shown how deficient many fodders are in necessary feeding elements and how chemical changes occur in the animal frame on account of the low feeding value of many of them, which really cause slow starvation, assisted by climatic conditions.

The elements found deficient in the brain and nerves are nitrogen and phosphorus, which are supplied in some degree by the empirical remedies. But the diseases really result from a deficiency of certain protective bodies in the food termed "vitamines" which give the aroma to hay and chaff. They are chemical substances easily altered by heat and other agencies and they act as nerve food. Those in milk stand heating better than those in fodder, but still the fluid loses much of its value by lengthy heating. These substances have hitherto been sadly neglected in feeding experiments upon which they have so great an influence, and when they are absent from the food, the animal has to draw upon the small supply in its own tissues resulting in failure of the processes of life.

Record Length of Animals' Horns

Mr. A. O. Hume, writing in *The Field*, gives some data regarding the maximum length observed in the horns of various animals. The record is held by the Argali, a native of Thibet, with a length of 5 ft. 7 in.

On Dry Land.

Rising from the Water.

The Benoist Flying Boat*

THE new "flying boat" of the Benoist Aircraft Company, in St. Louis, is the second of its type in the States to be placed on the market. While it resembles most of all the French Donnet-Leveeque, it has the Deperdussin style of control, using a wheel to operate ailerons and a push and pull on same wheel to elevate or lower and steer with a foot bar. A novelty is the unique radiator placed below the upper propeller shaft.

The planes are standard Benoist surfaces, the same as used in the tractor machines, of 5-foot sections, 46-inch chord, with a camber of 2 inches. The rudder and elevator is also standard, the elevator measuring 10 feet by 28 inches and the rudder 3 feet by 3 feet. Both the elevator and rudder flex for control, using springs with oak strips in place of ribs. The spread over all is 42 feet 2 inches. The distance between planes is 5 feet. Goodyear fabric is used for covering, double surface.

No vertical surface is used at the rear. Steel tubes of ⅞-inch and ½-inch diameter guy the rudder and elevator post.

The control wires are in duplicate and run exposed (through tube guides on elevator and rudder beams) to the side of the boat, where they enter through guides.

The boat is built of spruce, 5/16 inch thick on the sides and 3/8 inch on bottom, unlaminated. Horizontal and cross ribs are 6 inches apart. A 3/8-inch keel of spruce runs the length of the boat. The bow has a metal and wood frame, over which canvas is stretched, and fastened by a strip of wood the length of the boat. The rear half of the boat has a rounded top surface similarly constructed. There are three steel shod runners, 1 inch square, running the length of the bottom to protect the hull. There is an oak skid at the extreme rear and a small wooden rudder for turning in the water. This is connected with the air rudder. A 3-inch step is located under the center of pressure on the wings and fitted with air tubes to relieve suction. The hull has three compartments, with check valves in each. The boat measures 23 feet 10 inches long by 26½ inches at its widest part.

The motor is a 6-cylinder 75 horse-power Roberts 2-cycle, Bosch equipped, driving by Diamond roller chain (1-inch pitch, 5/8-inch wide) at crank-shaft speed, a Benoist 8-foot 6-inch diameter propeller, by 5-foot pitch, the sprocket shaft being a 1½-inch hollow steel tube. Ball thrust bearings are placed in containers at the front and rear ends. The engine itself is located on two beams, 1 inch by 8 inches of spruce, which rest on the bottom of the boat, and built integral. The lower plane is open in the center section and an aluminium hood covers the motor. The exhaust is carried outside the boat, but not muffled.

Landing.

A 1¾-inch steel tube distance rod extends from the engine sprocket to the propeller sprocket. At the top end the inside is threaded to receive the ball-bearing housing, and, therefore, is capable of adjustment for tightening or loosening the chain.

The propeller shaft is housed in a steel tube riveted to the bearings. The sprockets have 18 teeth and are 6 inches in diameter. New Departure ball bearings, 5/8-inch balls are used.

The passenger is placed behind the operator, directly in front of the motor, the same as the regular Benoist tractor. The controlling system is dual, allowing a passenger to control the machine if it is desired. The machine has a carrying capacity of three passengers, besides the pilot, the same as the standard Benoist plane, which now holds the American record with three passengers and pilot, made at Chicago during the last international meet by Tony Jannus.

The machine will also be capable of landing on land by being equipped with wheels, which may be raised or lowered by the operator at will by means of a lever.

The weight of the machine is 1,004 pounds empty. All wires are stranded Roebling cable.

* For the data here given we are indebted to *Aeronautics*.

Requirements for Scout Type Military Aeroplane

GENERAL REQUIREMENTS.

1. Inclosed body.

2. Protective armor for aviators and engine. This armor shall be made of chrome steel and about 0.075 inches thick. The armor shall be subject to the Ordnance Department penetration test for small-arm fire before being placed on any machine.

3. The following instruments and radio equipment shall be placed on each machine by the manufacturers and shall be considered a part thereof:

1. Tachometer.
2. Compass.
3. Aneroid barometer.
4. Barograph.
5. Map holder.
6. Pad and pencil holder.
7. Clock.
8. Angle of incidence indicator.

All of the above instruments shall be of the make and type approved and furnished by the Signal Corps, U. S. Army.

4. Provisions for a radio apparatus shall be made on each machine. This apparatus shall be furnished by the Signal Corps, drawings and specifications of which will be furnished to the manufacturer by the Signal Office. The base for the generator shall be part of the engine base. The generator will be driven by chain or gear from the engine unless a generator is selected which is mounted as part of the engine. The hanging antenna should be as nearly under the center of gravity as possible. This antenna shall be arranged to unwind readily from a reel and fixed so that it can be cut loose when desired with some foot mechanism. It is estimated that the weight of radio telegraphic apparatus will be about 75 pounds.

All of the above instruments and the keys for operating the radio apparatus shall be within easy reach of the pilot and observer.

5. The power plant of each aeroplane may be designated by the Chief Signal Officer, U. S. Army. When so specified, it shall be given a six hours' test on the block to determine its horse-power, speed, gasoline and oil consumption before being installed in the machine. The horse-power of the motor will be designated by the manufacturer who will be responsible that the aeroplane fulfills the actual air tests when the motor is turning out the horse-power that he specifies. The Chief Signal Officer will be responsible for the reliability and horse-power of any power plant that it specifies or purchases for installation in aeroplanes.

6. Upon delivery for tests the manufacturer will furnish the following data concerning the aeroplane:

(*a*) Weight.
(*b*) Normal angle of incidence in horizontal flight.
(*c*) Gliding angle.
(*d*) Gasoline and oil consumption of engine.
(*e*) Safe increase angle of incidence.
(*f*) Two blueprints of engine and aeroplane.

THE FOLLOWING AIR TESTS SHALL BE PASSED BY EACH AEROPLANE BEFORE IT IS ACCEPTED BY THE GOVERNMENT.

1. The aeroplane must carry two people with seats located to permit the largest field of observation for both.

2. The control must be capable of being used by either pilot or observer.

3. The machine must be able to ascend at least 2,000 feet in 10 minutes, while carrying a live load of 450 pounds, and fuel and oil for 4 hours' consumption. This live load will be made up of the operator and observer and such other weight as may be put in the inclosed body to make up the 450 pounds. The live load does not include the weight of the instruments and radio telegraphic equipment, which are part of the machine. This live load is to be carried in all the prescribed flying tests except the test in paragraph 10.

4. The machine must be capable of being transported by road, in which case its width must not exceed 10 feet. The construction must be such that it can be assembled for flight within one hour by six men.

5. The engine must be capable of being so throttled as to allow one person to make a flight without any other person assisting. This test to be made by the operator starting the engine and making a flight without any assistance.

6. The machine must complete a continuous flight for four hours, the first part of which shall be a non-stop, cross-country flight of at least 180 miles over a course designated by the Board conducting the tests. The flight may be completed over the aviation field.

7. The machine must have a minimum speed of not more than 38 miles per hour, and a maximum speed of not less than 55 miles an hour. The maximum and minimum speed must be measured by the machine flying over a course.

8. The machine must be capable of landing on and flying from harrowed ground and long grass within 100 yards.

9. The machine must be capable of safe gliding.

10. The efficiency and reliability of the system of control must be demonstrated as follows: The aeroplane must be capable of executing a figure eight within a rectangle 500 by 250 yards, without decreasing its altitude more than 100 feet upon the completion of the figure eight. This test may be made by the aviator alone.

11. Manufacturers must provide a name plate for each machine giving necessary data, such as maker's type and serial number. Painting of names or similar data on any part of the machine is prohibited.

12. The manufacturers shall furnish the demonstrators for all tests.

13. The system of control must be of a pattern approved by the Board of Officers conducting the tests.

14. The suitability of each machine for military purposes shall be determined by a Board of Officer Aviators appointed by the proper authority, who shall conduct all tests.

15. The following desirable features will give the machine a higher rating under paragraph 14:

(*a*) An effective silencer with cut-out on the engine.
(*b*) An actual flight in a 20-mile wind without damage to machine.
(*c*) Engine started from within the inclosed body.
(*d*) An efficient stabilizing device.

Fig. 1.—Thomson Spectrum of the Heavy Rare Gases..

Triatomic Hydrogen and Other Researches in Molecular Physics

Sir J. J. Thomson's Latest Report

Fig. 2.—Thomson Spectrum of the Light Rare Gases.

We have on several occasions (Scientific American Supplement, January 20th, 1912, page 41; October 26th, 1912, page 268) previously reported on Sir J. J. Thomson's work on positive ray spectra—his method of "weighing the chemical atom," which seems destined to throw a flood of new light on problems old and new. On January 17th Sir J. J. Thomson lectured before the Royal Institution on "Some Further Applications of the Method of Positive Rays." A report of this lecture has appeared in *Engineering*, and is reproduced here.

The first application which the lecturer dwelt on concerned the analysis by the aid of positive rays of the residues of liquid air, which Sir James Dewar had lent him. They contained the rare gases of the atmosphere, and had been separated by Prof. Dewar into two portions, one of the heavy and one of the light gases. Taking the heavy gases first, Sir Joseph exhibited the photograph which we reproduce in Fig. 1. [The photograph shows the curves in duplicate as starting more or less from the center, the position of no deflection; the duplication is produced by reversing the magnetic field, so that the deflection is first upward and then downward. For details see our previous articles on this subject, in particular Scientific American Supplement, No. 1921, page 269.] In the upper half of the figure the lowest curve was that of mercury, which was found on all the plates when mercury pumps were used; the atomic weight of mercury was 200.6, and measurements showed that the curve corresponded to particles of that mass. The next line above was that of xenon, atomic weight =128 [130 is the value given in the International Table of Atomic Weights]. The strong line above that, again, was due to krypton=82. Still further up argon (40) and neon (20) were to be seen; the curves of still lighter gases higher up were better studied on other photographs. The chief point of interest was that all the curves corresponding to heavy particles were accounted for, and it was thus established that the atmosphere did not contain any still unknown heavy gases.

Passing to the lighter rare gases (Fig. 2), Sir J. J. Thomson pointed out that above the mercury line were some air lines (presently to be referred to), and then the argon and neon lines strong; above those, again, lines corresponding to some nitrogen still left in the gas mixture, and high up helium and hydrogen. The novelty of this photograph was the faint line, just below the neon line, which indicated an atomic weight of 22. There was no element of that atomic weight known, and there was, indeed, no room for it in the periodic table of Mendeleieff.

It might possibly be a compound between neon and hydrogen; but none of the rare gases were known to form compounds. Perhaps Mendeleieff's table was sometimes interpreted too rigidly; for iron, nickel, and cobalt (atomic weights ranging from 56 to 60) had to be grouped together to fit into the table. There was a possibility, however, that the curve 22 might belong to particles of carbon dioxide (molecular weight, 44) carrying a double charge whose m/e would be 22. He had at first thought this view probable, because he had also obtained a faint curve 44. But cooling his gases once again with liquid air had made the curve 44 disappear, while the obscure line 22 had remained. On two occasions he had also observed, when experimenting with a bulb charged with helium, a line corresponding to mass 6; that might be regarded as a helium-hydrogen compound, He H_2 (He=4, H_2=2); but he had only observed that line twice and failed to discover it four times.

Going back to the heavy rare gases (Fig. 1), Sir Joseph pointed out that most of the curves ended, not at the zero ordinate, but at a certain distance from that ordinate, while the mercury and krypton lines extended nearly up to the zero spot, though that peculiar ordinate which marked the end or head of the curve in most instances could be discerned even in these cases. In other words, the head of the electrostatic displacement in strong fields was only one eighth of the normal displacement. Measuring the normal distance[1] of the head from the original spot, he found that mercury approached the zero within one eighth of that distance, and krypton within one quarter. That would indicate that the mercury atom was able to carry up to 8 charges (instead of the normal unit charge), and krypton 4 charges. Cases of this kind were not rare, and Prof. Thomson showed another photograph on which the discharge had been passed through mercury vapor; seven (or possibly eight) curves could be distinguished, corresponding to mercury atoms with 1 (mass 200), 2 (m/e 100), 3 (m/e 66), 4, 5, 6, 7, and 8 charges. Mercury was the only element with which 8 charges had been observed; some elements (argon, nitrogen) would acquire 2, or even 3, charges. In the case of mercury, however, the atoms which produce the head of the curve (near the zero) must have eight times the energy possessed by normal positive atoms, though there was no other actual evidence of an atom carrying 8 charges. That would indicate that these atoms had lost eight corpuscles. Very briefly discussing these features, Sir J. J. Thomson remarked that there were only two kinds of ionization; the one was due to the cathode rays when one corpuscle was knocked off; the other was due to the collision of the mercury atoms with positive rays, which caused eight corpuscles to be knocked off. Thus only two curves should be obtained; the others (with from two to seven charges) were produced by the recombination of the most highly charged atoms with one or more corpuscles. These arguments found support in the fact that the mercury spectrum could not be reduced to one series; there were three different Doppler displacements.

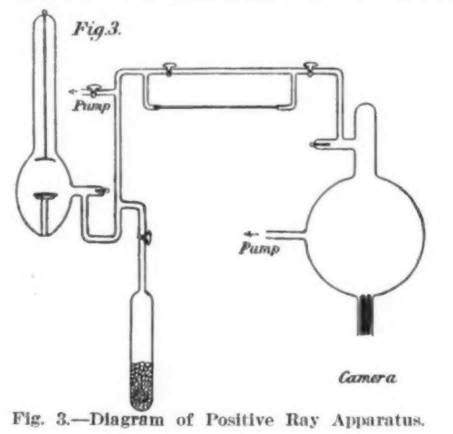


Fig. 3.—Diagram of Positive Ray Apparatus.

[1] In Scientific American Supplement, No. 1921, p. 270, it was pointed out that the kinetic energy of a particle passing beyond the cathode is proportional to the electric potential through which the particle carrying one charge falls before it reaches the cathode. Hence, in general there will be a certain definite maximum kinetic energy corresponding to the whole potential drop across the Crookes dark space in the discharge tube, with a corresponding minimum displacement on the plate. Hence the parabolic curves end fairly sharply on the left at the point here referred to by Sir J. J. Thomson as the "normal" head of the curves. Evidently, if a particle carries 2, 4, or 8 charges its kinetic energy will be 2, 4, or 8 times greater than for a single charge. In such case the head of the curve is found correspondingly nearer to the zero ordinate.

The lecturer then turned to the apparent discovery of a new gas by this method. He had occasionally observed a line of atomic weight 3, which could only belong to hydrogen (atomic weight 1, molecular weight 2), because there was no other element of smaller atomic weight than helium (4). Such a line might be due to a body H_3 analogous to ozone (O_3). The number 3 might also be explained as due to carbon atoms with four charges (12/4 =3); but the line 3 was seen when both the lines 12 and 6 were entirely absent, and it was hardly likely that this line C/4 should alone appear. But the line 3 was itself as elusive as the sea serpent; it might be seen once, and then disappear for months, and it had taken him a long time to find out something about the conditions of its occurrence. Yet the study of this line 3 was most interesting, because it corresponded to so small a mass; in the cases of higher values (greater masses) many different interpretations became possible.

In his study of this line, he had tried bulbs charged with all gases, and finally he had experimented with the gases given off by metals. Metals, metallurgists were quite aware now, retained considerable amounts of gas with persistency. Iron had been heated for six months, and still continued to give off some gas. When a metal was heated up to a certain temperature, the gas generation would finally become very feeble; but on heating it then to a higher temperature. more gas would appear—just as with water of hydration—and cathode ray bombardment would finally bring out more gas still. Sir Joseph had made his experiments with the apparatus illustrated in Fig. 3, the metal lying on the little table in the bulb below the cathode. The bulb was joined to a charcoal tube, to a pump, and a second bulb for photographing the positive rays, through a system of tubes containing a capillary glass tube in a shunt, which was supplied with two taps. By means of the pump the gas could be drawn off, while a fresh supply of gas could be introduced through the capillary. The object of the arrangement was to maintain different pressures in different parts of the apparatus. Iron, copper, nickel-oxide, etc., in this apparatus, gave the line 3 after bombardment, not before, though heating liberated plenty of gas. The helium line had also appeared, but it would as a rule not survive a second bombardment (if withdrawn by the pump after the first), while the line 3 would come out strong after twenty hours' bombardment and removal of the previously liberated gas. Fig. 4 shows the gas given off by iron, as analyzed by this method, before cathode bombardment of the iron (left half of photograph) and after the bombardment (right half of photograph). On this right half the three spots, starting from the top, are due to the hydrogen atom (small dot), the hydrogen molecule (big spot), and the new gas (smaller spot, not visible on the left half). Prof. Thomson also demonstrated the cathode bombardment of iron; the gas given off changed the appearance of the glow, and if sufficiently continued would have stopped the discharge by spoiling the vacuum.

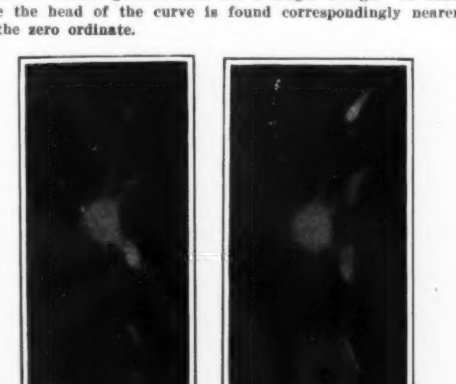


Fig. 4.—The Third Spot from Above in the Right Photograph is due to H_3.

During his investigation, Sir Joseph proceeded, he had found that lead taken from the roof of Trinity College Chapel, at Cambridge, gave off enormous quantities of gas when heated in a quartz tube, the helium line 4 and the line 3 being just visible at first. When the temperature was raised so that the quartz almost fused, and two thirds of the lead boiled away, neither of the two lines could be found in the gas liberated. But when the one

third of the original lead left was bombarded by cathode rays, both lines were discerned. These various experiments suggested that the gas corresponding to the new line 3 need not be stored in the metal, but might be produced, partly at any rate, by the bombardment, somewhat after the manner in which ozone was produced from oxygen by the silent discharge. But freshly prepared lead (precipitated as lead tree by zinc from lead acetate) gave no line 3 at all, while the purest lead in the market (from Kahlbaum, of Berlin) did give the lines 3 and 4, though less distinctly than the lead from the chapel roof. Meteoric iron again yielded both the lines.

The nature of the gas of the line 3 was still obscure, Sir Joseph concluded. Ozone O_3 was very active oxygen O. But this gas, if modified hydrogen H_3, was not active; it would not explode when sparked with oxygen. Metals which absorbed hydrogen, like palladium, liberated the hydrogen on being heated; he had tried this way, but the line 3 could not be traced in this hydrogen. It was noteworthy that there was room for an element of atomic weight 3 in Mendeleieff's table. That element should resemble fluorine, the most energetic element known, which attacked almost all bodies, including glass. Now his new gas, Sir Joseph remarked, was inert, and could be kept in glass tubes; yet that argument was not conclusive, because, Sir James Dewar had told him, really dry fluorine would likewise be inert. Thus the researches of the last months, in which photography had claimed much time, had left the question of the origin of the line 3 undecided. His store of the gas was not much over 1 cubic millimeter altogether, and he had been unable to study the spectrum for this reason. Incidentally this shows the superiority of the new method over spectrum analysis.

It will yet be granted that the method of analysis by positive rays is wonderfully convenient for dealing with exceedingly small quantities of substance. That the difficulties of the apparently simple experiments must not be underrated is sufficiently marked by the fact that besides Sir J. J. Thomson and Profs. H. von Dechend and W. Hammer, who simultaneously took up this line of research, no others seem to be working in this field.

Counting Atoms by Scintillations*

How the Individual Atom is Made Visible

By E. Marsden

It is well known that there are three principal types of radiation from radioactive substances designated α, β and γ. The first of these types, the α rays, or α particles, are single atoms of helium carrying a double elementary positive charge and moving initially with a velocity of the order 2×10^9 centimeters per second or one fifteenth the velocity of light. Different radioactive products emit α particles of different speeds but the speed is characteristic of the product. The α particles are very easily absorbed by material substances, the swiftest known, those from thorium C, being completely absorbed by 8.6 centimeters of air and the slowest known, those of uranium I, only penetrating 2.5 centimeters of air at atmospheric pressure.

The second type of radiation, the β rays, are known to consist of electrons or isolated elementary negative electric charges. They travel with enormous velocities varying for different products, and also for the same product up to as much as 0.998 of the velocity of light. The β are not so easily stopped as the α rays, traveling on the average about one meter in air before they are stopped.

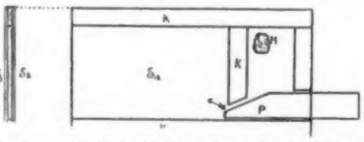
The third type of radiation, the γ rays, differ from the two preceding types in that they appear to be electrically uncharged. They are similar to very penetrating Röntgen rays, but their exact nature constitutes the battling ground of many rival theorists, for the problem appears also to involve that of the fundamental constitution of light waves. The γ rays seem to be closely connected with the β rays in much the same way as Röntgen rays are connected with cathode rays. All radioactive products which emit γ rays also give β rays, although certain products are known which emit γ rays without any appreciable β radiation.

One of the most remarkable of the properties of the various radiations is that of producing luminescence in certain substances on which they fall, and more particularly remarkable is the scintillating property of the α rays. This property was first discovered by Sir William Crookes, and independently by Elster and Geitel, in 1903, but five years elapsed before its full significance was recognized; for it is now known that each scintillation is produced by a single α particle or atom of Helium. Crookes made a screen by dusting Sidot's blende (phosphorescent crystalline zinc sulphide) on glass. On bringing up a source of radium the screen lit up with a greenish phosphorescent light which, when examined under a magnifying glass, was found to consist of a number of scintillating points of light.

Subsequent work has shown that many other substances show this scintillating property though the scintillations are generally fainter than with zinc sulphide; the best known substances being willemite (a mineral containing zinc silicate) barium platinocyanide and diamond. Many of these materials appear to require the presence of some impurity; thus pure zinc sulphide does not show scintillations while some of the purest diamonds fail to respond to any of the radium radiations. In nearly all cases also the scintillating substances appear to lose their sensitiveness under prolonged action of the α rays, and for this reason the zinc sulphide screens of Crookes's spinthariscopes after a time need renewal. Diamond and willemite are more stable than zinc sulphide, for they retain their scintillating power longer, while barium platino cyanide, on the other hand, is very rapidly transformed under the action of α rays.

It was at first thought by Becquerel and others that the scintillations produced in zinc sulphide, for example, are the direct result of the mechanical fracture or cleavage of the crystals by the α particles, since it is well known that zinc sulphide is very sensitive to mechanical shocks. Recent evidence, however, appears to discredit this hypothesis and points to the conclusion that the scintillations are in some way the result of the enormous local ionization produced in the zinc sulphide by the α particles; for it is well known that an α particle produces about two hundred thousand ions, before its energy is absorbed.

In 1908, Rutherford and Geiger succeeded in detecting the emission of a single α particle by an electrical method and were thus able to count the α particles from a given quantity of radium. By comparing this number with the number of scintillations produced under proper conditions on a zinc sulphide screen they were able to show that practically every α particle produces a scintillation. Thus the scintillation method can be used for quantitative measurements in radioactivity and this method has since proved of very great value in such investigations; for the electrical method of counting α particles is cumbersome and requires very special apparatus. A piece of glass or other transparent material is coated with small crystals of zinc sulphide and the observations are made in a dark room with a microscope of magnifying power in the neighborhood of fifty. A good combination is a Leitz No. 0 eye-piece with a No. 4 or No. 3 objective, while it is better to have the screen very slightly illuminated so that the eye may be continuously focused on it. The source is arranged so that the scintillations appear at a rate not greater than about ninety per minute and not less than about five per minute, these rates being generally the limits for accurate counting. In some cases it is necessary to have the source and screen in a vessel at reduced pressure owing to the limited "range" of the α particles. The scintillations are timed with a stop watch. They do not appear regularly but are distributed according to chance, and to obtain an accurate estimate a large number of scintillations must be counted—in fact, the scintillation method has given an interesting experimental confirmation of the laws of probability as applied to radioactive disintegration.



A Simple form of Spinthariscope, a Device for Observing the Scintillations Produced by the Impact of Helium Atoms (α Particles) on a Phosphorescent Screen.

Perhaps one of the most interesting experiments with scintillations is that originally used by Geiger and Marsden in the detection of the short-lived α ray products after thorium and actinium emanations. Thorium emanation is a gaseous radioactive product emitting α particles and followed by a second α ray product whose mean life is only one fifth of a second, while actinium emanation is similarly followed by an α ray product of mean life only one three hundred and fiftieth of a second. The illustration shows a "drawing room" modification of the apparatus designed by Mr. F. H. Glew.

S_1 and S_2 are two zinc sulphide screens lying one above the other and separated by thin paper strips K.K. The upper screen is very thinly coated so that it is practically transparent and scintillations on the lower screen can be seen from above. M is a source of thorium emanation consisting of a very small amount of mesothorium. The emanation diffuses between the screens in an amount regulated by the small strip P.

Consider an atom of the emanation which disintegrates between the screens emitting an α particle which produces a scintillation on either the upper or lower screen. The atom of thorium A produced from this emanation atom has an expectation of life of one fifth of a second before in its turn it disintegrates, and gives off a second α particle which causes a scintillation on either S_1 or S_2. Thus the result is two scintillations, one following the other with about one fifth of a second interval. These scintillations appear on about the same area of the screens and can be observed by an ordinary pocket magnifying glass or microscope. In the case of actinium emanation the scintillations are given off with an average interval of one three hundred and fiftieth of a second, so that the interval cannot be distinguished by the eye, the result being apparently two scintillations at the same time, generally very slightly separated in position.

The scintillation method has also had an important application in the study of the scattering of α particles by matter. When a parallel pencil of α particles is incident on a thin metal foil, the individual α particles suffer deflection by the atoms with which they come in contact and the beam as a consequence becomes scattered. The distribution of α particles in the scattered beam can be observed by scintillations and from this distribution considerable evidence can be drawn as to the electrical forces inside the atoms causing the scattering. Thus it has been shown that all atoms are constituted in some respects similar to small models of our solar system. They appear to have a very strong central charge consisting of a number of elementary charges equal to half the atomic weight. This central charge appears to be concentrated within a volume extremely small compared with the size of the atom and to be surrounded by electricity of the opposite sign which on our analogy may be compared with planets.

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Scarcity of Elevator Literature

Nearly all, if not all, the various branches of power-plant engineering are well represented in engineering literature except that pertaining to elevators. By this statement we do not mean to infer that the few books devoted to this subject are unworthy of commendation. We do deplore the lack of such literature.

In modern city life the elevator is an extremely important factor. It is said that more people travel on elevators in New York city in one year than in all the subway, surface and elevated railroads combined. The problem of safely carrying so many passengers is serious.

In large office buildings the care of the elevators is only a part of the engineer's duties. True, the watch engineers in the very large office building plants have little to do directly with this work as it is intrusted to the care of a foreman and crew who do nothing else. But, the chief engineer is responsible to the management and the public for his foreman, and watch engineers are future chiefs.

If it were not for the work of trained inspectors of the insurance companies the number of fatalities due to wrecked elevators would be startling. This is no reflection upon makers of elevators or the men caring for them. The latter do well; the wonder is that they are so successful. In seeking to learn more about their work these men look for books covering the subject, and are astonished to find that there is no complete work available. The elevator makers are none too generous or responsive to requests for information concerning their machines. There is one commendably complete book on hydraulic elevators, but, to the best of our knowledge, none thoroughly treating electric machines. Some engineering books make a pretense of treating them, but the information given is far too meager to be of much value.

We were fortunate to obtain and publish during the years of 1908 and 1911, inclusive, a series of articles on electric elevators by the late William Baxter, Jr. This series made up the most thorough and practical treatise on the subject ever published. But this is not enough. A treatise on elevators embracing all kinds is sorely needed.—*Power.*

Lightning Protection of Buildings*

The Devices Employed Must Be Calculated for High Frequency Currents

By Ernst J. Berg†

In looking over recent articles dealing with lightning and lightning protection one is struck by the prominence given to protection of electric transmission lines and electric apparatus, while practically no contributions have been made to the subject of protection of buildings since the famous work by Sir Oliver Lodge years ago. Yet the protection of buildings unquestionably is as important as the protection of transmission lines and there are thousands of people interested in protecting their homes to every one interested in a transmission line.

To people living in cities the subject is, however, of little or no interest. Experience has shown that the extensive networks of wires, metal roofs, etc., are usually ample for protection. The man living in the country, however, is very much concerned, as experience has shown that in certain localities at least it is indeed tempting Providence not to have some lightning-rod scheme.

While little is known about the source of the electric energy, fortunately, due mainly to the researches of Sir Oliver Lodge, a fair amount of knowledge exists about the nature of its discharge—of lightning itself. Lodge first suggested that there are at least two distinct kinds of discharges; one which is relatively quiet and which results from the gradual breaking down of the air between the object struck and the charged cloud; the other which is a violent secondary discharge caused by a primary discharge in the vicinity.

The first kind follows the well known laws familiar to the electrical engineer—laws that deal with more or less permanent conditions. The nature of the discharge is governed by the resistance, inductance and capacity of the path. The path itself is almost certain to be the rod on account of the conducting streamers above it.

The second kind is more complex and the laws that it follows are less thoroughly understood. There is no conducting path above the rods because there may have been no potential difference between them and the surrounding air before the discharge. Thus the rods may well be missed and the discharge enter any portion of the roof and find its way to ground through the building. To guard against these it would seem that the entire roof should be of metal, or at least largely covered by a metal network.

Prof. Fleming has compared the first with the slow combustion of gun powder placed in a room and carefully lighted, the second with detonating powder.

ELECTRICAL CONSTANTS OF LIGHTNING RODS.

It is generally recognized that a lightning discharge is oscillating and that the oscillations are of high frequency, perhaps from 100,000 to several million cycles per second. At these frequencies the electric constants of conductors are very different from those normally.

In the passing of high-frequency currents, energy is expended as heat at the surface of the conductor and as electric radiations in the surrounding space.

The object of the lightning rod is to form a path for the discharge, a path offering much less obstruction than any path through the building. If the ohmic resistance were all important this could well be done by using a very large copper rod, but at these very high frequencies the inductive obstruction, or impedance, is measured in tens or even hundreds of ohms, whereas the ohmic resistance may be but a small fraction of an ohm.

ELECTRIC CHARACTERISTICS OF LIGHTNING.

The greatest number of lightning discharges takes place inside of clouds or between adjacent clouds. These discharges involve usually rather moderate voltages, as has been shown by Steinmetz, but while very interesting are hardly within the scope of this paper. The knowledge of the nature of lightning discharges from cloud to earth is, however, of the greatest importance in studying the efficiency of lightning rods.

Unquestionably such discharges take place not only at moderate voltages, but also at voltages which are exceedingly high; this latter being the case when the charged cloud is separated from earth by a layer of more or less dry, moisture-free air.

Under these conditions the distribution of potential may be quite uniform, and the air as a limiting case may be charged to its breakdown point all through its mass, then the potential difference may be exceedingly great, perhaps hundreds of millions of volts. The maximum value of the discharge current may also be very great, reaching several thousand if not hundreds of thousands of amperes, as may be judged from the consideration of the following simple and apparently conservative case.

An area on the surface of the earth 100 feet square is subjected to the discharge of a cloud or part of a cloud, also 100 feet square, at a distance of 1,000 feet. In this case the capacity is approximately 0.000027 microfarads, a very small capacity indeed, something like that of the smallest Leyden jar. If the electric stress as assumed were uniformly distributed throughout the air space separating cloud and earth, and if the disruptive strength of air is 30,000 volts per centimeter, a potential of 912 million volts would exist between cloud and earth just before the stroke. The electric charge, that is, the amount of electricity stored, would be 0.025 coulombs, a very small value when considered by itself. The energy stored would, however, be great on account of the high difference of potential. It would be 11,200 kilowatt-seconds, corresponding to the energy of almost a pound of dynamite. This energy must be expended in heat and electric radiation, partly in the stroke before it reaches the rod, partly in the circuit of the rod. The higher the frequency the greater is the relative amount radiated. With a small copper rod the energy radiated at one million cycles is perhaps 50 times as great as that converted to heat in the rod. With a small iron rod, however, the two quantities are not much different. Thus the iron rod will convert more energy to heat and yet only slightly more impede the discharge. The number of oscillations of the current in the iron rod is therefore less than with copper, and the discharge less violent.

While in every discharge almost an infinite number of frequencies undoubtedly are represented, it is probable that one is preponderating. Were it permissible to consider that the frequency in the discharge after it reaches the rod is governed only by the electrical constants of the rod, the wave length would be somewhat more than four times the height of the rod. This would mean with an ordinary dwelling, having a rod of say 50 feet, about 5,000,000 cycles. If on the other hand the effect of the rod is hardly noticeable and the frequency is governed by the distance between cloud and earth, the frequency will be much lower, say 250,000 cycles, with a distance of 2,000 feet between the cloud and earth.

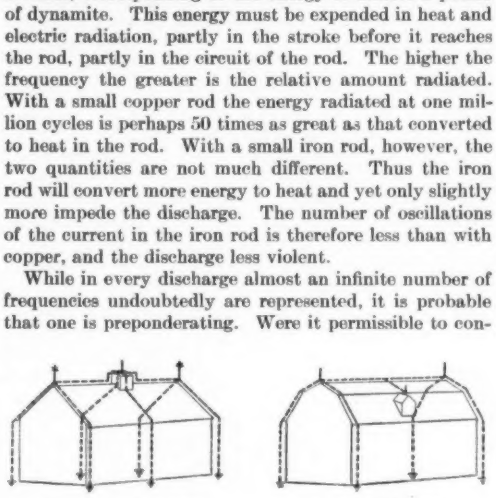

Fig. 1.—Satisfactory Arrangement. Fig. 2.—Undesirable Arrangement.

Figs. 1 and 2.—Lightning Rods on Small Buildings.

In the first case the drop in potential per foot is about two million volts, in the second case only nine thousand volts. The first case, I believe, gives an idea of the conditions of a secondary stroke. It is of very high frequency and may be the result of the discharge of the air immediately surrounding the rod rather than the entire air between cloud and earth. The discharge area is in this case difficult to estimate; it may be quite limited or it may be quite great.

Assuming again an area of 100 feet square and calculating the voltage and capacity, it is found that the capacity is increased in the same proportion as the voltage is decreased; therefore, the charge and maximum value of the current remains unchanged. The maximum value of the current, would be, say, 750,000 amperes, and the drop per foot of rod about 2,000,000 volts.

It is evident that such discharge would jump several feet in the air rather than travel 1 foot in the conductor. (The drop in potential of 2,000,000 volts per foot corresponds to 2 feet striking distance between parallel planes and perhaps 10 feet distance between projecting masses of metal).

The second case, I believe, is approached when a lightning discharge takes place from cloud to rod after a conducting path has been prepared by means of streamers. It is the first, the quiet type of lightning mentioned in the beginning of the paper.

Thus is seen how a single lightning rod may be expected to take care of low-frequency discharge from cloud to earth, but is entirely inadequate to cope with a violent secondary discharge, even if perchance it hit the rod instead of the building proper.

Were this illustration then at all representative it would mean that one lightning rod, while offering some protection, is entirely inadequate to cope with the situation. If the building were grounded by 10 rods the condition would be much improved. The maximum drop per foot would then correspond to a moderate air space and the lightning discharge would probably be confined to the system of rods.

Before discussing the approximations involved in this elementary discussion it may be well to see the effect of a larger cloud, or perhaps better a larger section of a cloud discharging through the rods. If the areas were doubled, twice as many rods would be required for the same amount of protection. If the areas were the same, but the cloud were only one half as far above the building, the voltage would be lower, but the capacity greater, and the conditions in the original assumption would apply.

PRINCIPAL UNCERTAINTIES IN THEORY.

The principal uncertainty of this theory lies in the estimate of voltage and frequency. Regarding the voltage, it is not likely that even in perfectly dry air the electric stress is uniformly distributed throughout the space; it is probably higher at the cloud and at the building than in the column of air separating them. The effect of this would be to lower the potential and therefore the charge and energy involved. It is probable that, as stated previously, in discharges in clouds and between clouds the potential may be only moderate because it is likely that the discharge takes place from drop to drop at rather low values. In the case of the discharge to ground, however, this suggestion does not seem reasonable, when the lightning strikes through clear air. Furthermore, unless the voltage is extremely high the energy discharged could not be great enough to do what is frequently done.

Regarding the frequency, a great deal has already been said. It seems reasonable that discharges take place at frequencies as low as 100,000 cycles and as high as several millions. While with the former considerably more energy is likely to be involved, it seems reasonable to expect that a rod is of very considerable protection, whereas with the latter a very large number of rods would be required.

CONCLUSIONS AND ANSWERS.

What conclusions can then be drawn regarding the best method of protection: what answers can be given to the questions often asked?

"Is there any real advantage in the installation of lightning rods or do they draw lightning and thereby add to the danger?" Experience seems to have settled beyond reasonable doubt that if properly installed, lightning rods afford considerable protection. A large number of instances might be quoted, but suffice it here to mention only one near at hand. Before equipping the University of Illinois buildings with rods, three fires were caused by lightning; since that time, though the number of buildings has been greatly increased, there has been no damage from lightning.

Any lightning rod "draws" lightning if by that expression is meant that it prepares under certain conditions an easier path for the lightning discharge than would be the case if it were not there. The conducting streamers issuing from the rod tend to equalize the potential between earth and cloud and thus diminish the severity of a stroke and possibly prevent it altogether. Yet it may also be argued that unless there are many such streamers the rod cannot always cope with the situation and a stroke may result from them. This feature is dealt with later under another heading.

"Can a building be perfectly protected from lightning?" The answer must be no, except perhaps in the case of a thoroughly grounded all-metal building.

"How much protection does a lightning rod afford?" Unquestionably some if properly installed, but it may make matters worse in some cases. Assume for instance that a large building is equipped with a high, but broken, rod or a rod having poor joints or a high resistance to ground, say, several hundred ohms, which undoubtedly sometimes is the case. Such a rod could serve the function of equalizing the potential between cloud and earth almost as effectively as a good rod, and were there only a sufficient number of them it is conceivable that the neutralization of potential would be so complete as to make a flash discharge practically impossible. A building having one rod only, however, is considered at present. The rod is assumed as projecting considerably above the building. If the electric tension is great, unquestionably streamers are emitted, the air above the rod is made fairly conductive and thus the discharge is invited.

The question is then: "How can such a rod take care of a discharge?" It has been shown how the discharge current frequently is very large and while the ohmic resistance of the rod is practically immaterial as long as it is at all reasonable, it must not approach or exceed the normal value of the impedance. In a rod, say, 30 feet long, the

*Condensed in the *Engineering News* from a paper before the Illinois State Electric Association, October 24th, 1912.

†Professor of Electrical Engineering, University of Illinois.

ohmic resistance of even the smallest practical iron conductor is a fraction of an ohm only and the impedance is perhaps 30 to 75 ohms, depending upon the height and frequency of the discharge. It is easily seen that a poor joint may have many times this resistance; therefore, when the discharge encouraged by the streamers from the defective rod strikes the building it finds the rod entirely inadequate to cope with the situation. The voltage drop in the rod is so great that it is far easier for the current to split up in a number of paths and enter through the buildings than to confine itself to the rod.

An apparent paradox thus exists. The rod should have good joints, should have good ground connection, and should be mechanically secure against breaking; although the shape of the rod, its metal or general dimensions, are rather immaterial.

"How many rods should be used?" The answer is, the more the better. The protection afforded ought to be, roughly speaking, proportional to the number of earthed rods. Half a dozen ground connections to a house 100 feet by 50 feet seems nothing out of the way.

How should they be placed? They should always be placed outside of the building and it is indeed a question whether the vertical part of the system, that is, the rod proper, should not be some little distance from the wall and possibly even insulated therefrom. The rods should be a considerable distance from gas pipes, stove pipes, water pipes and balconies or places where persons might be during a storm.

A small house might be protected as shown in Fig. 1. There are five or six ground connections, one at each corner and one or two from the chimney. A horizontal rod follows the ridge of the roof and is connected to earth by the several ground connections.

Heated gases coming from a chimney are apparently themselves good conductors, or more probable are instrumental in collecting and forming a path of charged particles constituting good conductor for lightning discharges. It seems conservative, therefore, to have a metal conductor crossing over the chimney opening. Such a conductor should be made of copper on account of the chemical effect of fuel gases on iron.

Two small spires each having many points are shown. These are unquestionably of some advantage in that through them there is a continuous equalization of the potential between cloud and earth. It seems, however, as if their height should be conservative. A projection of a few feet seems quite enough. To be effective in their office these spires should have several points; but the expense of using platinum or something similar seems hardly warranted, because the amount of current radiated from the points is insignificant before the "brush discharge" begins, and when such discharge takes place it matters little whether the points are rough or sharp.

Each tower or other projection of a building should have direct ground connection, though connected with the other lightning-rod system.

In Fig. 2 is shown what in my opinion is an unsatisfactory arrangement of rods. A small dormer is supposedly protected by an independent short rod connected by a long wire to the main system. It seems unlikely that the discharge would travel many feet to reach the main rod when by striking through the building it can reach ground in most cases with greater ease. The attic room, supposedly protected, is in my opinion endangered by the rod. Protection would, however, result if the dormer rod were directly grounded.

Metal gutters should be connected to the lightning-rod system and also at their lower extreme to ground.

A high factory or power-plant chimney needs good protection; two or three rods do not seem too many, and the opening of the chimney should be crowned by some simple copper-rod construction.

"What kind of material should be used?" In cities, where after all the damage by lightning is small, there is always more or less fuel gas and soot in the air and copper seems best. But I can see no electrical advantage in having a stranded cable—a solid rod is as efficient. There is a very slight advantage in a flat ribbon, but the advantage is very small and the mechanical difficulties with a ribbon are greater than with a rod.

In the country, galvanized-iron rods seem best for two reasons: (1) They are cheaper; (2) their electrical constants are, if anything, better than those of copper. Again an apparent paradox is met. It has been said that the material, size and shape of the rod was rather immaterial and yet now iron rods are recommended. The reason is that the first statement applied to the ability of the rod to discharge the current with the least drop of potential, whereas other factors also enter—factors which, to be sure, are of a secondary importance.

The old idea that the rod carries the electric charge to earth and that that is the end of it is fallacious. The earth is one plate of the condenser, the cloud the other, and whatever energy is stored between them has to be consumed in some way. It is done by heating the rod and by sending our electric radiations. The higher the resistance of the rod the greater is the energy converted to heat, and thus the smaller the number of oscillations of the discharge current necessary to dissipate the energy. Iron has considerably higher effective resistance than copper, and thus has an advantage.

Perhaps the point will be clearer by stating that as far as impeding the flow of the current is concerned the ohmic resistance of the rod is immaterial as long as it is at all reasonable. As far as affecting the duration of the discharge is concerned, however, the higher the resistance the shorter is the time and the less violent is the disturbance. [The resistance should not be concentrated, as at joints, for this would concentrate the energy and destroy the rod.—EDITOR.]

Lodge's experiments and theory show conclusively that there is no advantage in copper over iron. Copper may have mechanical advantages under certain conditions, for instance in cities where the atmosphere is charged with soot and a variety of fumes. Galvanized iron has the advantage of cheapness, with a possible electrical superiority.

"What should be the shape and size of the rods?" While flat conductors have a very slight advantage, it appears too small to be considered seriously. A round wire or a pipe can conveniently be handled and seems therefore preferable. In the installation of the rods, sharp bends should be avoided as much as possible. There is little or no advantage in using large expensive copper conductors or cables; a size mechanically satisfactory is likely to serve all electrical purposes. Expensive sharp points offer little advantage over ordinary rather blunt points. The rods may advantageously terminate in a number of points projecting only a short distance above the part to be protected.

"How should ground connections be made?" They should be of low resistance, and therefore the rods should preferably terminate in moist soil. "Salting" the ground may be an advantage, but the experience with such grounds is not sufficient to warrant its adoption unless an occasional inspection is made. In many cases excellent connection can be made by driving a galvanized gas pipe a few feet in the ground.

"Should water, steam and gas pipes in the building be connected to the rods and grounded?" This is debatable. On the whole it would seem most conservative to leave them alone, especially the gas pipes. The water pipes, which are always grounded, may, however, advantageously be connected to the lightning-rod system under ground.

"Is it dangerous to stand in a draft during a thunderstorm?" A building having its windows and doors open certainly affords a chance for the entrance of air, perhaps ionized air made conducting by a previous discharge. It is, therefore, safer to keep the house closed during a violent storm.

"Is it safe to stand near a lightning rod?" From the preceding discussion this seems hardly safe. It is well to keep away not only from the rod, but from chimneys, kitchen ranges, metal pipes, etc.

It is finally of interest to draw attention to the fact that the damage by lightning in cities is relatively small and that so far the modern sky scraper with its vast amount of steel appears to be lightning proof.

In conclusion, I wish to emphasize the fact that after all we know little about lightning. I have tried to incorporate the experience of many investigators and observers and am particularly indebted to Sir Oliver Lodge's numerous writings and experiments on this subject.

Beginnings of Famous Universities

THE University of Oxford has the reputation of having been founded by King Alfred in 872.

The first college of the University of Cambridge was founded by Huga, Bishop of Ely, in 1257.

The University of Paris was founded in 1240.

The first university in the German Empire was at Prague, Bohemia, 1348.

The Czar Alexander I, founded the Universities of St. Petersburg and Moscow in 1802.

The oldest Spanish university is that of Salamanca, founded in 1240.

The University of Copenhagen, Denmark, was founded in 1479.

The University of Upsala, Sweden, was founded in 1477.

The oldest Italian universities are Bologna, founded in 1200; Padua, 1222; Naples, 1224; Genoa, 1243; Perugia, 1276; Macerata, 1290. There were nine more founded between 1300 and 1550. Italy was the greatest resort of students for the higher education in the Middle Ages.

Trinity College, Dublin, was incorporated by royal charter in 1591.

The University of Edinburgh was founded in 1582 by a charter granted by King James VI, of Scotland.

Harvard University had its beginnings at Newton, afterward Cambridge, Mass., in 1636.

Yale University had its beginnings at Saybrook, Conn., in 1700 and was removed to New Haven in 1716.

Columbia University was chartered as King's College in 1754. The name was changed to Columbia College in 1785, and to Columbia University in 1896.

Princeton University, founded in 1746, was chartered as the College of New Jersey, and did not assume its present name officially until its one hundred and fiftieth anniversary in 1896.

William and Mary College (first steps taken toward establishing it in 1617) was erected at Williamsburg, Va., and charter granted in 1693.

The first common schools established by legislation in America were in Massachusetts in 1645; but the first town school was opened at Hartford, Conn., prior to 1642.

The University of Pennsylvania had its beginning at Philadelphia, Pa., in 1740. It was chartered in 1753 as the Academy and Charitable School in the Province of Pennsylvania, and received a further charter as a college in 1755. Its present title dates from 1791.

The University of Jagielle, of Cracow, Poland, where Copernicus received his education, was founded in 1364 by the Polish king Kazimer the Great, and endowed by a later Polish king, Jagielle, in 1400.—*The American Educational Review.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, MARCH 8, 1913

Published weekly by Munn & Co., Inc., Charles Allen Munn, President
Frederick Converse Beach, Secretary and Treasurer;
all at 361 Broadway, New York

Entered at the Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876). . per year $5.00
Scientific American (established 1845) . . . . . . " 3.00
American Homes and Gardens . . . . " 3.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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